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Contents for March

Editorial.....*F. M. Dawson* 345
A Cordial Invitation Awaits..... 348
Education for Intelligent Living...*F. L. Wilkinson* 352
Education in U. S. and England.....*M. J. Kelly* 358
Symposium on Nuclear Engineering
Nuclear Engineering.....*D. W. Cardwell* 362
Programs of Oak Ridge Institute...*W. G. Pollard* 367
Engineers for Atomic Energy .....*P. N. Powers* 370
Subject Matter in Nuclear Engineering.....
.....*M. D. Peterson* 375
Nuclear Engineering at N. Carolina...*C. K. Beck* 378
Structural Engineering as a Profession . *O. G. Julian* 383
Metallurgy in the Mechanical Curriculum.....
.....*R. F. Eisenberg* 387
Problems in Industrial Engineering...*H. R. Beatty* 389
Nomination Blank..... 392
Employment in Small Industries.. *A. R. Hellwarth* 393
Labor Relations and the Engineer.....*A. Startz* 397
Freshman Themes.....*J. H. Pitman* 402
Teaching Aids Exhibit.....*S. G. Lutz* 406
Timely Tips—Combined Variable-Load Equations.
.....*R. T. Hinkle* 409
Candid Comments..... 413
Summer Schools for 1951
Engineering Drawing 412
Humanistic-Social 382
Mechanical Engineering (Thermodynamics) 414

Departments

Section Meetings—416 Sections & Branches—361, 374
College Notes—377 New Members—417

The American Society for Engineering Education

IT'S "LOADED" WITH BETTER TELEPHONE SERVICE

Twenty of the Bell System's newest small loading coils—shown at left—are housed in the long black case, mounted in a cable splice. This type of installation permits economical extension of city cables to serve out-of-town subscribers.

MANY more wires can be crowded into a cable sheath when the wires are fine. But normally, wires don't transmit as well when they are fine and closely packed.

Bell engineers long ago learned to make wires do better work by loading them with inductance coils at regular intervals. The coils improve transmission and let messages travel farther. But originally the coils themselves were large, heavy and expensive. The cases to hold them were cumbersome and costly too.

So year after year Bell scientists squeezed the size out of coils. To make magnetic cores of high permeability they developed Permalloy. Tough but extra-thin insulation permitted more turns to a core.

New winding machines were developed by the Western Electric Company. Coil size shrunk to one-fiftieth. Some—like the one shown above—can be mounted right in cables.

The 15,000,000 coils in the Bell System today mean thinner wires, more wires in a cable—more economical service for you. They demonstrate once more how Bell Telephone Laboratories work continually to add to your telephone's value.

BELL TELEPHONE LABORATORIES

Working Continually to Keep Your Telephone Service Big in Value and Low in Cost

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Editorial

President's Report

Throughout the year, the ASEE has been actively working with the Engineers' Joint Council and with Government agencies in an attempt to get a satisfactory solution of the problems of engineering manpower as related to the proposed Universal Military Service Bill. The following developments will be of interest to members of the ASEE.

Engineering Manpower

Your Society has cooperated with the Engineers' Joint Council in the formation of an Engineering Manpower Commission. This Commission was formed to make recommendations relating to "the most effective utilization of engineers in the national effort."

The ASEE representatives, particularly Deans Hollister and Saville, have attended numerous meetings and have taken a leading part in the formulation of the Commission policies. They have performed a distinguished service by bringing the entire technological manpower problem into sharp focus among the agencies in Washington, D. C. Dr. Prentice, Chairman of the ECAC Military Affairs Committee and Secretary of the Commission also deserves credit for his energetic contributions to this important undertaking. The Commission has issued a report and members have presented testimony before Congressional hearings on the UMST Bill.

In addition to numerous detailed proposals, the Commission broadly recommends:

1. The national registration of student engineers and engineers in critical fields.
2. The establishment of a National Engineering Personnel Board to review and classify the registrants, place qualified persons in a "reserve" and make selections from this "reserve" for critical skills in military, civil defense, and industrial occupations.
3. The establishment of programs similar to the war time ESMWT programs.

The report also calls attention to the impending shortage of engineers resulting from reduced registrations in engineering colleges.

The ASEE has sent to engineering colleges over 150,000 copies of the reprint "Acute Shortage of Engineers Seen As Enrollment in Colleges Slumps" published in the New York Times. The colleges of the country, in turn, have sent these out to high school students as a means of increasing freshman enrollments in engineering.

The Engineering Manpower Commission is preparing material to be sent to high school students throughout the country calling attention to the sharp decline in engineering enrollments and pointing out that this offers excellent opportunities for students interested in engineering.

Report of the Thomas Committee

An Advisory Committee to the National Security Resources Board known as the "Thomas Committee" has presented its recommendations relating to engineering manpower. Briefly this proposal would provide for the following:

(a). All qualified eighteen year olds would receive four months basic training after having completed high school education.

(b). A limited number of persons who have completed basic training would be permitted to enroll in ROTC units in the colleges to provide a supply of trained officers for military service.

(c). A limited number of students, selected on the basis of national examination, would be permitted to enroll in a Reserve Specialist Training Corps after they have completed their basic training.

(d). A National Scientific Personnel Board would be established to accumulate and analyze information relating to the industrial and military requirements for scientific manpower. It would also advise on the number of scientific and engineering students to be selected for the Reserve Specialist Training Corps, and would allocate manpower requirements to its own Regional Boards. The Regional Boards would classify persons with scientific and engineering skills who are liable for military service including those in the Reserve Specialist Training Corps and others in the Reserve Corps who have completed the twenty-seven months of military service. A person so classified would be referred by the draft board to the N.S.P.B. for assignment to the military forces, strategic industries, or the colleges for service.

(e). All junior and senior students presently taking science or engineering would be permitted to defer their military service until completion of their college work. Also a limited number of seniors would be permitted to enroll for graduate study, the number of such persons being recommended to the President by the N.S.P.B. Persons so deferred would be required to agree to accept employment as recommended by the N.S.P.B. and the President.

Universal Military Service Bill

The Coordinating Committee on Relations with the Federal Government of the ASEE, under the Chairmanship of Dean Saville, is cooperating with the Engineers' Joint Council in studying the proposals for universal military service. At present, the bill provides that a maximum of 75,000 men would have their military service suspended and would be permitted to return to college after a short basic training period. These persons would be selected by such civilian officials or agencies of the government as the President may designate and shall be selected "from such fields of medicine, the sciences, engineering, humanities, and other fields determined by the President to be in the national interest." A student, whose military service has been suspended, may be required to serve the uncompleted portion of his military service within a period of ten years after completion of his school work, "unless such person performs other military or civilian services in the national interest for a period equivalent to such services." The Engineering Manpower Commission, along with American Council on Education and other educational associations, has recommended that the figure be not less than 75,000 per year instead of a maximum of 75,000.

The Engineering Manpower Commission has recommended that of the proposed 75,000 freshmen annually, between 45,000 and 50,000 should be permitted to study engineering.

The question as to what will happen to students now enrolled in colleges is still under discussion. The original Selective Service Act, of which the new U.M.S.T. Bill is an amendment, gives the President authority to defer persons whose employment in "industry, agriculture, or other occupations, or whose activity in study, research, or medical, scientific, or other endeavors is found to be necessary to the maintenance of national health, safety, or interest." Under this provision, the President could defer any or all students now enrolled in engineering colleges. There has been considerable discussion of the possibility of deferring all college students until they have completed their college work, but there seems to be no positive indication that such action will be taken.

Induction of College Students

The following directive has previously been sent to the deans of engineering colleges. This directive was sent by General Hershey to the local draft boards, relating to the induction of college students:

"Postpone induction for thirty days of all college students who are being graduated at this time and having their statutory postponement terminated for that reason. This thirty day postponement is to enable such graduates to obtain employment in essential industries. Upon showing of such employment, local boards should be requested to re-open the case of such registrants and to consider classification anew."

Educational Testing Service

In this issue is an announcement of new pre-engineering tests which have been developed by the Educational Testing Service. These tests are shorter, less expensive, and easier to administer than previous tests. They have been proven to be reasonably predictive of scholastic success in engineering. It is urged that the deans of engineering colleges and administrators of testing programs give serious consideration to the possible adoption of these tests. The E.T.S. is a non-profit corporation, financed by endowments from some of the leading philanthropic foundations. The organization has on its staff some of the best testing experts in the country. They are responsible for the college entrance board examinations, graduate record examinations, and many other examinations, including several in professional fields. Dr. Pemberton Johnson, formerly Director of the Purdue University Testing program, is in charge of construction of the engineering tests. The Committee on Selection and Guidance of the ASEE is working closely with the E.T.S. This Committee and the officers of your Society feel that a great deal can be accomplished along with the lines of construction of new and better tests as well as establishing national norms if the engineering colleges will support these tests. The E.T.S. has reduced costs to a figure which would be difficult for colleges and universities to compete with on a local scale.

Respectfully,
F. M. Dawson,
President ASEE

ANNUAL MEETING

MICHIGAN STATE COLLEGE

East Lansing, Michigan

June 25–29, 1951

A Cordial Invitation Awaits— Michigan State College Annual Meeting June 25-29, 1951

Michigan State College was a relatively small university before World War II, but it stands today as the eleventh largest institution of higher education in the nation. Not only does it have the student body, but it has the educational philosophy, breadth of curriculum, faculty and physical facilities to match.

Here are some little-known facts about Michigan State College. Enrollment of students reached a post-war peak of 16,243 during the fall quarter of 1949. In the fall term of 1950, enrollment stood at approximately 15,000. Total faculty, including teaching, research and extension, numbers over 2000. Physical facilities on the Spartan campus have grown tremendously since the end of World War II through a vast building program. In the field of inter-collegiate athletics, all-around performance of Spartan teams ranks with the best in the nation. The Western Conference voiced its approval of MSC's athletic prowess when it voted in May, 1949, to accept Michigan State as a member of the Big Ten.

The institution has come a long way since 1855, when it was founded as Michigan Agricultural College, first of its type in the nation. Carved out of the pines in Michigan's Lower Peninsula on the outskirts of Lansing, this institution has a tradition in agricultural teaching and extension work that can boast no equal, for it blazed the trail for the land-grant movement which was to follow in the 1860's. These institutions drew upon the graduates, educational innovations and intellectual philosophy developed at MSC.

In the 1920's, the East Lansing college, boasting an enrollment of nearly 3,000 students, began to flex its muscles and prepare for bigger and better things. After curricula in liberal arts and applied science were added in 1921 and 1925, it was natural that in 1925, the Aggies of Michigan Agricultural College became the Spartans of Michigan State College.

Michigan State is proud of its heritage, and service to the people of Michigan has remained the guiding philosophy of the institution since its founding as the "state college." The 15,000 students in the college classrooms are but part of the broad service philosophy of Michigan State College; a program which extends in all directions to spread scientific knowledge to the far corners of the state.

Through the Agricultural Experiment Station, the Co-operative Extension Service and the Continuing Education Service, an additional 100,000 Michigan residents each year are given assistance and training by the college.

Educational Facilities and Programs

Today, students have a choice of approximately 70 curricula, with 58 of these offering graduate degrees. Among the courses available are agriculture, home economics, hotel administration, chemistry, physics, engineering, medical technology, nursing, police administration, business, art, pre-medicine and pre-law. The administration of these courses is divided into eight main schools. They are: Agriculture, Home Economics, Engineering, Veterinary Medicine, Graduate Studies, Science and Arts, Business and

Public Service, and the Basic College, a two-year program of general education.

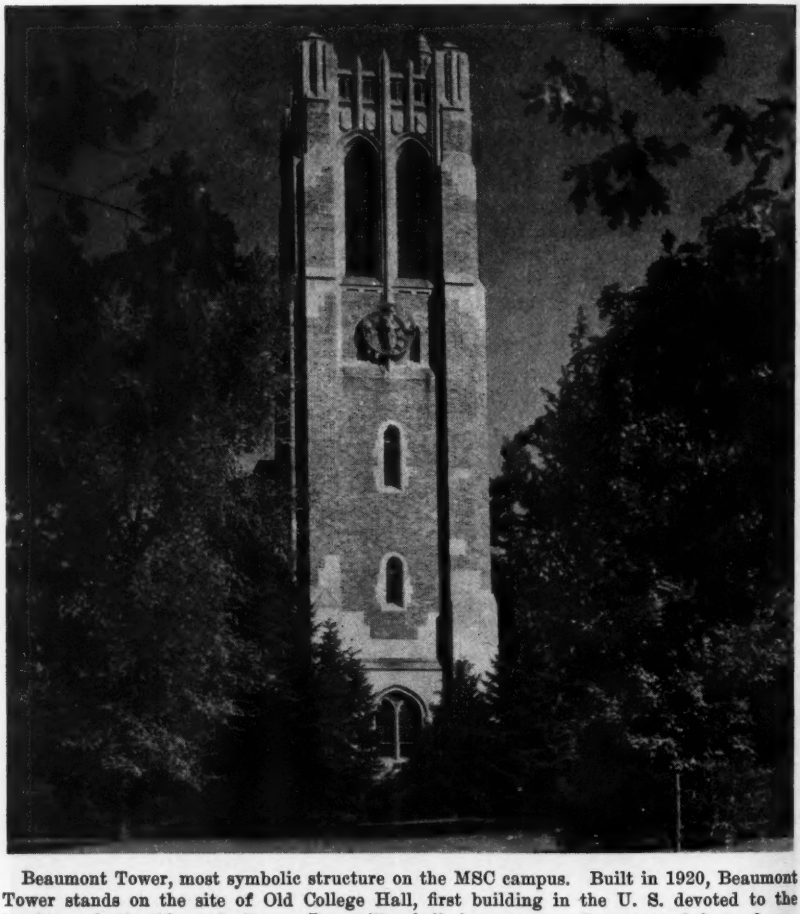
Although the school is in every way a university, officials of Michigan State prefer to keep the term "college" to avoid confusion with their sister Big Ten member, the University of Michigan.

MSC got the jump on most of the nation's colleges and universities in preparing for the post-war rise in enrollment. A self-liquidating program completed in 1940 added eight major buildings to the Spartan campus at no expense to the public.

In 1946, Michigan State launched another building program, designed not only to provide educational facilities for the returning veterans, but also to adequately serve the increasing demands of Michigan people for college educations and numerous other services.

Now nearing completion is a post-war building program which has added 17 major buildings to the East Lansing campus. Also included in the project were modernization of the MSC Union and Macklin Field Stadium, and erection of 11 apartment buildings for married faculty and students. Six large classroom and laboratory buildings, a steam generating plant, seven dormitories and a dormitory food service building have been constructed since the end of World War II. Approximately 60 per cent of

Modern Design: Shaw Hall, newest of five men's dormitories on the Michigan State College campus, accommodates approximately 1600 students. It is one of the largest dormitories in the United States.



Beaumont Tower, most symbolic structure on the MSC campus. Built in 1920, Beaumont Tower stands on the site of Old College Hall, first building in the U. S. devoted to the teaching of scientific agriculture. Its carillon bells have rung students to and from classes for the past three decades.

these structures were built on a self-liquidating basis, at no cost to the public.

Scheduled for completion early in 1951 is the modern seven-story Kellogg Center for Continuing Education. It is being constructed primarily to accommodate more than 100,000 Michigan citizens who come to the campus each year for the college's broad program of adult education. The structure is being financed largely through a grant from the Kellogg Foundation of Battle Creek.

Also included in the post-war building program is an addition and extensive renovation of the college's veterinary medicine facilities. The structure, being built through legislative appropriation, is scheduled for completion in the fall of 1951.

College officials point that the current

construction program, impressive as it is, only makes good in part the accumulated deficiencies of years. Until the current state-financed program was undertaken in 1946, not a single classroom or laboratory structure had been erected on the Spartan campus at state expense since 1931. There is an urgent need for many additional structures, among them a new library building, and an animal industries building.

Although Michigan State has greatly expanded its physical facilities since the war, the natural beauty of the Spartan campus, known the world over, has been maintained. Visitors to the campus are immediately impressed by the careful planning which has preserved the full beauty of such natural landmarks as the Beaumont Oval—its many varieties of trees and expanses of rolling lawn; the Red Cedar river, which divides the main campus from South Campus; the Beal Pinetum, just east of the campus proper; the Beal Botanical Gardens; and the Horticultural Gardens.

Along with its natural beauty, the Michigan State campus has a cosmopolitan personality. Its students come from every walk of life and from every part of the world. Included in its enrollment each year are students from every state in the nation, and from more than 50 foreign countries and U. S. possessions. Even with this wide-spread geographical distribution, Michigan students still constitute about 80 per cent of the campus enrollment.

Michigan State College has always endeavored to maintain a top-flight teaching faculty to administer these courses. The Spartan faculty is studded with national authorities in almost every field.

An important factor in Michigan State's growth has been the dynamic leadership of President John A. Hannah. He has served the college since his graduation in 1923, when he became an extension specialist. He was named secretary of the State Board of Agriculture, governing body of the college, in 1935, and president in 1941. President Hannah is also recognized as one of the nation's top educational leaders, having served as president of the American Association of Land Grant Colleges and Universities during 1949, and as chairman of the organization's executive committee in 1950.

In the field of sports, Michigan State's record demands respect. Not only has the East Lansing school one of the best athletic plants in the nation, but Spartan sports teams have consistently provided better-than-average competition for the nation's top teams. Michigan State engages in intercollegiate competition in 13 major sports.

Macklin Field Stadium has a seating capacity of more than 50,000. Jension Fieldhouse, largest non-commercial building in the State of Michigan, provides approximately 13,000 seats for basketball games, in addition to housing athletic offices and training facilities for other sports.

The 1950 football team ranked 8th in the nation, defeating such teams as Michigan, Notre Dame and Minnesota. Michigan boxers, undefeated in dual competition, copped third place in the 1950 NCAA tournament, following second place ratings in 1948 and 1949.

Spartan swimmers lost but one match, to perennially strong Ohio State, while winning nine meets. The baseball team has a 19–9 record and the cross-country squad won the NCAA crown, after having copped the NCAA, IC4A and NAAU contests in 1948. In all other sports, including several having predominately sophomore squads, Michigan State always proved a formidable foe in spite of won and lost records.

Education for Intelligent Living*

By FORD L. WILKINSON
President, Rose Polytechnic Institute

I take my text from a statement made by President-emeritus Hotchkiss of Rensselaer Polytechnic Institute, who in an address before the American Institute of Consulting Engineers several years ago made this statement:

"I believe that a man should be credited with culture when he has four attributes: when he is able to see in their proper perspective the factors of the problem before him; when he is able to have a true sense of the relative value of men and of things; when he is able to distinguish the true from the false; and fourth, a summary of all, when he has those attributes of a well balanced mind which enable him to live intelligently in his environment."

If the engineer is to become such a cultured man and possess these four vital attributes where may he be expected to commence their development? Does the public school system in which the embryo engineer spends twelve of his preparatory years guide him and interest him in his early march to the attainment of culture? Certainly those of us who meet freshmen each fall have doubts that their major ambitions have been concerned with more than the attainment of sufficient credits in certain courses prescribed for college entrance. These "credits" are largely earned through parrot-like quotations from the texts in use and, like all such learning, immediately lost and irreverently buried. All of this and more is told in a scathing article by Albert Lynd, entitled "Quackery in the Public Schools" appearing in the March issue of *The Atlantic Monthly*. Mr. Lynd goes further and, as far as one of his readers is concerned, brings convincing proof that we can expect little help from the prior education of most of those for whom we must seek to create a desire for the culture of Dr. Hotchkiss.

We in the engineering schools have, and I think quite properly, undertaken the task of the whole education of the engineer. Any by "whole education," I mean that we have assumed the responsibility of offering to the neophyte professional the opportunity to prepare himself to attain "those attributes of a well balanced mind which enable him to live intelligently in his environment."

Potential Leaders of World Thought

I wonder how many of us engineers turned teachers realize how deep that responsibility goes, how extensive that environment is. Is there any phase of human and physical conduct not a factor in the engineer's environment? His whole field, his only excuse for being, impels him to take a vital and necessary part in the political, social and economic betterment of mankind. And his perhaps once limited environment now extends to horizons so broad that we as his preceptors might well lie awake at night and worry over our responsibility, not that he is inadequately versed in the application of nature's laws nor that his technical mistakes will haunt us, but that he is ignorant of all else and cares little how ignorant he is. Our records as teachers of science and technology are unusually good. Engineering has definitely passed out of

* Presented before the Missouri Section, ASEE, April 1, 1950.

the limbo of the empirical arts and into the realm of the rational. I believe that we in the engineering schools and colleges can take pride in being responsible for this tremendous professional advancement.

But we must accept partial guilt, among ourselves at least, of the charge that has been laid before our door time and again of restricting the young engineer's development to the point that his usefulness, influence and interests are not adequately developed for intelligent living. I do not hold with the majority of our accusers that the engineer's education is more stifling than is that of the average liberal arts graduate. In fact, I honestly believe, and think that you will agree with me, that the engineering graduate has a far broader and more beneficial education for himself and for society than does the non-scientific major with an A.B. degree from the average liberal arts curriculum. The point I wish to make here, and to emphasize, is that we have in our student bodies young men whose abilities are such that they may be the leaders of world thought and of world betterment and that we, as engineering teachers, may not be exerting ourselves adequately to that end.

Before the end of World War II this society organized a committee for Engineering Education after the War. I know from first hand that that committee worked earnestly and hard at its task of reporting to the Society. It took to heart all that others had said about our methods and our curricula. It made an earnest effort to analyze the engineer's environment and to suggest certain criteria for the curricula under which engineers should prepare for their profession. As you know, much was said concerning the humanistic-social stem of the engineer's education and the report even suggested that twenty per cent of the curriculum should be devoted to subject matter in these fields.

What has been the result? Meeting after meeting of engineering educators were devoted to the discussion of ways and means of "broadening" the engineering student's education, even as we are doing this evening. Engineering schools in universities with many humanistic-social programs within the liberal arts began pouring over their colleagues' offerings and selecting with their aid those deemed adequate for the broadening of the engineer. A few institutions, being unwilling to sacrifice any hours from engineering or technology, added another year to the curriculum, and one I know of decided that a student must enjoy the broadening advantages of the liberal arts for two years before being admitted to the rigors of the engineering school. Others, not blessed with association on the campus with a college of liberal arts, expanded their faculties in the fields of the humanistic-social studies and developed sufficient new courses to provide the sacred twenty per cent or a reasonable approach to it. On the surface, therefore, the engineer's curriculum has been broadened and he may be expected to acquire through the change a desire and a yen for culture generated in courses gleaned from offerings outside the engineering school or its departments.

Shifting the Burden

Perhaps it is a step in the right direction and I am sure that the hours our students spend in these classes are helpful to them. But, somehow, I think that we as engineering educators have simply shifted the burden of developing the well-balanced mind. We seem to forget that though we may give up twenty per cent of a student's time to non-technical courses and to the instructors in these courses, he spends eighty per cent of his time with us.

Let us concede that four years is an all too short period to provide the technical and scientific background that an engineer must possess to practice in a creative profession. I think that we are properly jealous of every minute of the time that each student spends outside our

individual classrooms. I think that the engineering and science departments are exceedingly generous in granting to others twenty per cent of his valuable time. In fact, I am not too convinced that by this generosity we have strengthened our curricula as media for preparation for "living intelligently" in the young engineer's future environment.

The young man who selects an engineering education does it normally because of his interest in those practices with which an engineer is daily involved. He is inspired by the engineer's accomplishments in solving difficult problems of a physical nature and wants to meet those problems immediately. He, even more than his engineer instructors, resents every hour under the tutelage of any one who is outside the pale of his chosen profession.

I need not tell you that this aspirant for admission to the chosen circle looks upon any problem for which he cannot find or develop a suitable formula as something not worth his effort. I am afraid that we have encouraged him in this and have sometimes belittled the dispensers of culture among our teaching colleagues in the fields of more general education. So while we generously give him up to these gentlemen for twenty per cent of his time, we may perhaps strengthen his resistance to the influences he may receive from them by our own expressions of doubt concerning the value of the hours he spends away from us. Is it not foregone, then, that many students only *suffer* the divergence and look upon the courses they take in the non-technical fields as hours they must successfully pass in order to graduate; hours placed into the curriculum for the sole purpose of providing them with a few courses of less rigor in order that their loads may be somewhat lightened? And woe be the lot of one of our colleagues who teaches a course in the non-technical twenty per cent who should fail a student who stands well in science and engineering!

What I have tried to convey thus far is a doubt in my mind if the shift that we have made in an attempt to better prepare the engineering student for intelligent living has or will result in accomplishing the objectives we all seek and feel to be so important for the well being of all. I am desperately afraid that in shifting the responsibility or the burden, whichever you may feel it to be, to the shoulders of our colleagues outside the engineering school, we have neglected those cultures that we have within our own disciplines. I claim in all sincerity that within the scientific and technical curriculum there exist as many and more opportunities to develop those attributes of a cultured man as may be found in any of the more general disciplines of the colleges of arts.

Our whole professional life deals with an analysis of the many variables that exist in and affect scientific phenomena. We seek to control these variables and to make them perform to the advantage of some good end. We admit to limitations on our knowledge. When we state a law, we establish limits as to its usefulness and all our conclusions are restricted by limitations existing within a clearly stated premise. Is not this the very process through which we may hope to develop in the young minds who sit under us those attributes that enable one to "distinguish the true from the false," to "have a true sense of the relative values of men and of things"? And most certainly our disciplines are most effective in enabling one "to see in their proper perspective the factors of the problems before him."

No matter what the course, or in which collegiate environment it is taught, we have every means of providing a grand opportunity for those who sit under us to develop an analytical approach to every problem they may face. What is it then that may perhaps result in our graduating from the engineering curriculum men of little tolerance and understanding of anything outside the specific courses we have subjected them to? I think perhaps it may be that so intent are we in developing immediate proficiency in a narrow

specialty that we ourselves hardly recognize the complete usefulness of the tools we have at hand.

The danger of our program lies in the fact that we as individuals may not concern ourselves enough with the applications we might make of the methods we use so efficiently. While we are quick to doubt our peers and to exact of them the last ounce of proof in support of an expounded technical conclusion, we permit demagogues in all other walks of life to lead us by the nose and trouble little concerning the accuracy of their statements so pontifically pronounced. Sometimes we even quote as gospel the half-truths from such men as Westbrook Pegler, Drew Pearson and perhaps even Walter Winchell. Too often, we who are the most pronounced advocates of skepticism in the realms of science and technology are unusually receptive to any political, social or economic doctrine that may have a popular acceptance.

Not long ago an old gentlemen of my acquaintance from East Tennessee spent a winter in Washington with his daughter whose husband was a newly elected Member of Congress. He had little else to do than witness our national law makers in action. Upon his return, one of his friends asked him how he had enjoyed his winter's pastime among those who represent us at the seat of our Government. His reply was simply this: "I discovered up there that we have no 'law givers' any more." And I think that one of the reasons we have no "law givers" any more is because in our whole educational system from the primary grades through college, each of us who teaches is concerned too frequently with the problem of indoctrination. Each of us teaches and applies himself to developing in his student the highest possible proficiency in the narrow speciality he professes.

Education or Professional Indoctrination?

Today the average college teacher in English has become a specialist in Shakespeare, Milton or some obscure Elizabethan dramatist, or he may have devoted his life's work to speech or creative writing. The economics teacher may be too thoroughly specialized in finance, accounting or "what have you" in that field. In each of our students we look and pray for one whom we may interest and indoctrinate into the field of our specialized interest, and perhaps only tolerate the others who sit in our classes. Historians are notorious in their specialization so that it is almost impossible to find one sufficiently broadly trained and willing to devote his time to teaching a course that will hold the interest of non-history majors.

With several notable exceptions, when we place our engineering students in the hands of these specialists we only tend to narrow their education rather than to broaden it, and there are some within the ranks of the colleges of liberal arts themselves who declare that their colleges contain a larger majority of specialists than do the professional schools. I think that there is much truth in what they claim.

As I stated earlier in this discourse, we as engineering educators have elected to conduct an undergraduate school at college level. We deem it important that the young men we serve obtain a broad and general education together with their professional. We claim that the rigor of our technical courses is such that only those students with better than average ability may hope to survive. The vast majority of these superior college students begin and end their college courses in our classes. We may say, therefore, that our responsibility goes far beyond providing them with the fundamental educational background that will prepare them for technical proficiency in a limited environment. If we are to serve our nation well and, because of the position it occupies among other nations, the world, we must superimpose upon the technical, those influences that will develop "those attributes of a well balanced mind that will enable him to live intelligently in his environment."

I am definitely convinced that this cannot be accomplished through the implementation of the new curricula we have adopted. We can only succeed if those who teach neophyte engineers for more than eighty per cent of the time adopt an attitude that an engineering education contains as much or more of cultural value than any other. It means that engineering teachers themselves must have or must develop those attributes of a cultured man so adequately defined by Dr. Hotchkiss. We have, within our professional practices, the most wonderful attitudes and disciplines for this purpose. It is only needed that they be extended. Engineering is forever extending the discoveries in the solution of one scientific problem into many others.

This is accomplished by allying itself to no blind doctrine or "school of thought." And this same principle applied to the political, social and economic life, all within the ever-broadening environment of our graduates, can be the only education of the engineer for intelligent living.

I wish to repeat and to re-emphasize that the burden is on our shoulders and not on those to whom we have allotted a limited amount of the student's time, regardless of how great for good their influence may be. Our faculties must be composed of, in addition to men of outstanding technical abilities, men of such broad culture that they contribute the largest share in the development of the well-balanced mind in those young men who, because of the dependence of the world on their technical ability are to influence so largely the future of generations to come.

Inspiration in Education

Since assuming my present position, a little over a year ago, I have met with alumni throughout the country. One of the striking things about these meetings has been the tributes of these men to those who taught them. Some of these alumni are the leaders in business and industry and all of them are graduates of an engineering curriculum. These tributes are rarely directed to the content of the courses taught by the men they admired and revered but to the inspiration they received from their personalities and the intimate association with these great teachers which they had.

Just last week, one alumnus, who is the President of what is probably the world's greatest corporation, told me of the influence on his thinking of a grand old gentleman long since retired. This alumnus graduated as a civil engineer and the professor to whom he referred taught chemistry. He said that the example of this great teacher in the classroom and outside inspired in him the assurance that in scientific and engineering studies there was to be found all that one could need for intelligent and useful living. His life outside the classroom was one of service to the community and the students were justly proud of the respect for his integrity that was evident from the local citizenry. To be able to command that respect and admiration from students means the possession of qualities far beyond mere technical competence. To give of one's self and to inspire to culture and intelligent concern is what may be called the "plus of good teaching." And I think that you must agree with me that it takes that "plus" in the development of the well balanced mind among engineering students.

I entered the teaching profession from industry some seventeen years ago, wholly inexperienced in pedagogy and horribly conscious of my deficiencies. I approached my Dean, whose teaching experience encompassed some forty years, and asked for advice on "how to teach." I recall with what earnestness he said: "I do not know how to advise you. I think perhaps you would do well to look back over your college career and pick out the one among your instructors who inspired you the most, and emulate him." And he went on to say that he believed I should find that he was probably not one who had the greatest reputation as

a scientist or engineer but the one that stimulated my intellectual curiosity more than any other.

There immediately came to my mind a picture of Professor Morse of Columbia University, who, when I was privileged to sit in his classes, had passed seventy years and was teaching only one course. He called his course "The Philosophy of Design" and each meeting was for two hours with a ten minute rest period at the halfway mark.

He taught largely by analogy and into the field of the design of structures and machines he wove a philosophy of professional conduct and responsibility that will always be with me. Many of his illustrations were from nature and he dealt largely with man's efforts in technology to copy many biological processes and improvements. He started a lecture on columns one day by drawing on the blackboard with remarkable skill and from memory the evolution of man's tibia from the skeleton of the Neanderthal man to the frame of the modern. Each lecture was interspersed with morals nicely conceived and subtly presented to impress upon us the importance of a professional attitude of service with all it implies of an ever-widening responsibility beyond that of simple technical competence. And at the end of the term his examinations were all that any purist in the field of design could desire.

In reflection over the years since then I have been convinced that Professor Morse was retained on the Columbia Engineering School faculty long past retiring age because of his proficiency in inspiring those students who sat under him.

While I am ever conscious that I shall never be able to emulate Professor Morse, I do find myself critical of my teaching based on the "plus of good teaching" as exemplified by that grand old gentleman who gained his engineering reputation in 1876 as one of the principal designers of New York's Sixth Avenue Elevated Railway.

The importance of this "plus of good teaching" is greater today than it was a generation ago. I have the impression that in those days the threats to the freedoms we are supposed to enjoy were mild if not inconsequential. The graduates from engineering schools were relatively few in comparison with those from other colleges of higher learning and they could segregate themselves fairly well from those who influenced the political and economic life of the nation. The economy of the nation was far from being almost wholly dependent on the increased value of our materials through manufacture, and it is this influence on our economy that is almost entirely the sphere of the engineer and his brother, the scientist.

Today the products of engineering colleges scatter themselves into every field that influences our national economy and the maintenance of production and employment is one of their major responsibilities. They cannot be segregated from the rest. They must mingle with them and their attitudes and their philosophies will exert greater and ever greater influence on our national economy.

That they may obtain a start toward the acquisition of a well-balanced mind while sitting under us as their preceptors is our major responsibility, not to be shifted to the shoulders of others who I think to be no more capable that we to inspire to intelligent living. Let us not then be so greatly concerned that we pack into the curriculum of the young engineer courses and hours in this or that so-called social-humanistic study, but that we so conduct our classes and courses that the full significance of our great culture will develop men who possess in full measure those attributes of well balanced minds that will enable them to live intelligently in their ever-expanding environment.

God grant that we shall be able to meet this tremendous responsibility.

Educational Patterns in U. S. and England*

By MERVIN J. KELLY

Executive Vice-President, Bell Telephone Laboratories

It gives me pleasure to participate in the discussion of England's problems in higher technological education. I have listened with great interest to the material presented by the previous speakers. It appears that you are almost of one mind that something must be done to provide for the training of a larger number of engineers, but there are differences in viewpoint as to the best course to follow.

It is impossible for one from another country to have adequate background to recommend the educational patterns to be followed to provide your country with a large enough supply of men with the training that is best suited to your industry's needs even though he be familiar with your present organization of engineering education, the institutions where the training is given, and the place of the scientist and engineer in your industrial society. I shall certainly not attempt to do this. Rather I shall confine myself to a presentation of my country's applied science and engineering educational pattern and the place of the scientist and engineer in its industrial society. I shall also make comparisons of the numbers completing an engineering education in America and in your country and give my interpretation of the significance of the difference.

It is now generally accepted that an effective, dynamic and competing industrial society must have adequate structures of pure research in the physical sciences and in applied research, development, design and engineering for manufacture. These structures are built around specially trained men. To provide them there must be an educational system of adequate capacity and quality with curricula suited to the needs of the training of the variety of technical specialists that industry requires.

During the last 50 years there has been a tremendous expansion of industry in America. At the beginning of the century we were primarily an agricultural society. Today we have the largest industrial structure in the world. As a scientist in industry I have observed the last 30 years of this transformation. As industry has expanded and increased its scope, there has been a parallel increase in the volume of scientific and engineering education accompanied by a continuous improvement in its quality.

The two developments have had an intimate interrelationship. I am confident that the great expansion in the volume of our industry with an ever-broadening scope could not have come about had not our scientific and technical education structure undergone corresponding expansion and broadening with great improvement in quality.

In 1920 there were only 4600 engineering graduates in the United States. In 1950 the number was approximately 50,000. (This number is abnormally large due to the effect of war on the education programs of our young men but some 30,000 is the probable normal.) There are now some 137 engineering schools whose curricula meet the mini-

* Condensed version of remarks at the Conference on Higher Technological Education on 27 March, 1950 in the Auditorium of The Royal Society, London.

mum standard of the Engineering Council for Professional Development. (An agency of the Professional Engineering Societies.)

An earlier speaker has quite properly raised a question concerning the number of engineers educated in my country in comparison with the number educated here, even when the difference in total population is taken into account.

If 30,000 is taken as our normal present level of engineering graduates per year, I estimate that we are training of the order of ten times the number of engineers as is England when our population is only some three-fold that of yours. This disparity, I believe, is mainly due to the difference in the area of use of the engineer in the industrial society of the two countries.

Increasing Use of Engineering Graduates in U. S.

We now use the engineering graduate in a considerably wider range of our technological activities than is your practice. Some 30 years ago we used the engineer almost entirely to develop and to design. There were very few engineering graduates in manufacturing engineering, in the supervision of manufacturing operations or in the operations of the service industries such as electricity, gas and telephone. As technology became more complex it was increasingly difficult to realize the maximum benefit from the output of our young research laboratories when so large a fraction of the technological operations were done and directed by men without engineering training. From my own experiences in the early twenties in introducing electronic products into manufacture and use (remember that in the early twenties the electronics industry was in its infancy) I can give testimony to the difficulties of introducing so new, complex and precise an art into a manufacturing organization made up largely of non-technically trained men.

As these difficulties were recognized, engineering graduates were used in an increasingly large area of the technologic operations of our society. Through the years there has been a continuous increase in the area of use of the engineer in the activities of manufacturing, distribution and technical service. Now substantially all members of manufacturing engineering organizations are engineering graduates and the top few levels of management of manufacture are largely filled by engineering graduates. The distribution of industrial products and consumer goods is planned and directed by engineering graduates. The service industries in their management and technical operations are also manned increasingly by engineering graduates.

This trend toward the increasing use of engineering graduates in all sectors of industrial management and operations is continuing. The progress made in the three decades of my observation is tremendous. It is not surprising to find that with the growing population of engineers in all areas of industrial management and operations the senior man in the direction of a corporation, the president, is also becoming more and more a man of engineering training. The presidents of some of our largest industrial and service corporations are men with engineering training whose entrance to industry was through the door of the professional engineering job.

This broad extension of area of use of the engineer beyond the professional operations of development and design has been one of the most important elements in the rapid increase in our industrial power. I am confident that our technological progress would have been much slower and our country's industrial strength of a considerably lower order if our technical education system had not supplied the large volume of adequately trained engineers for use in the management and technical operations of an ever-increasing area of our industrial society.

If the technically trained man, the engineer, now occupied the same area in your society as he now occupies in that

of my country, it would be necessary for you to increase your engineering graduates by at least a three- to five-fold factor.

Evolution of Industrial Research Laboratory

Since our conference today is primarily concerned with engineering training, I have first discussed the engineering educational pattern and the place of the engineer in my country's industrial society. However, one will not obtain a balanced view of the relation of education to our industrial strength unless the training and place in our industry of the scientist, applied scientist and postgraduate trained research engineer are also presented. We shall now turn to this area.

The industrial research laboratory directed by men trained in the research methods of science had its beginnings in my country in the first decade of this century. Dr. F. B. Jewett of the Bell System and Dr. W. R. Whitney of the General Electric Company were among the first men trained as pure scientists with a working knowledge of the scientific research method. The laboratories they founded have become two of the great industrial laboratories of our country. More men trained in research at the doctorate level followed them into industry and the number of our industrial research laboratories has grown rapidly. There are now some 2500 in our country. In the early years substantially the only source of men for industry trained in the research method was our graduate schools of pure science.

Initially there was some difficulty in industry's obtaining its share of the men of highest quality trained in pure science. The environment that industry has established for them over the years, the freedoms that they enjoy and the monetary rewards are such that for many years industry has obtained its share of the most competent men trained in research in the graduate schools of pure science of our universities and technical institutes.

Initially the needs of industry for men of research were met almost entirely by selection from the graduate schools of pure science. Soon, however, the evolution of the industrial research laboratory accompanied by the growing complexity of technology developed the need also for men of research of the engineering type having more fundamental training in the sciences than can be obtained in the four year engineering course and with experience in research in an academic atmosphere.

This need has been met by the development of postgraduate courses in an increasing number of the institutes of technology and schools of engineering in the universities. Curricula have been developed leading usually to the Ph.D. degree but in some institutions a doctor of engineering is given as the equivalent of the doctor of philosophy. In 1949, 1150 doctorates in the pure sciences, physics, chemistry and mathematics, applied science and engineering were awarded. Approximately 400 were in the areas of applied science and engineering. Most of the 400 have entered the laboratories of industry and government. Also, a significant fraction of the 750 doctors in the pure physical sciences have taken places in our industrial and government research laboratories. While I have not been able to obtain exact data, it is my estimate that at least one half of the 1150 doctors of 1949 have entered research laboratories of industry or government.

The training of the graduate men in the institutes of technology and the engineering schools of our universities has had a most beneficial effect on the undergraduate curricula. The atmosphere of research and the contact at the research level of the faculties of engineering with industry have made for a much more stimulating and fundamental atmosphere in the undergraduate school. The graduate schools in applied science and engineering that are an integral part of an increasing number of our institutes and

schools of engineering and the industrial research laboratories that look to these graduate schools for a large fraction of their young research men are most essential and important links in our chain that transforms new scientific knowledge into facilities for man's use.

Ascendency of Graduate Work

There is evidence that in the more complex areas of industrial technology an even larger fraction of the creative technical staff than can now be obtained from the graduate schools of our universities and technical institutes could well have training beyond the four-year engineering course. The Bell Telephone Laboratories in the years since the war have established an on-the-job school of graduate training where it gives its four-year engineering recruits additional training in the sciences and in the technology of telecommunications at the postgraduate level. While this experiment is too new for final conclusions to be drawn, our experience indicates that substantial benefits will accrue in our development and engineering programs from the additional fundamental training that the young engineers are receiving.

In your plans for higher technological education the importance of graduate training in applied science and engineering to the doctorate level should not be overlooked. The amount of such training has been steadily increasing in our country and, with the continuing trend of greater depth and complexity in technology, industry's needs for such men will grow. I do not believe that a society having available to it only men trained in pure science for its applied science, in engineering research and fundamental development for industry and engineers with the equivalent of our four years of training for its specific development and design work for industry will have the required self-contained strength. It will not move as fast or be competitive with an industrial society that also has available an adequate number of men of the engineering type trained in institutes of technology and engineering schools to the doctorate level and with training in an academic atmosphere in the methods of scientific research.

Including this graduate training in our institutes of technology and schools of engineering is not only providing us with research men well-suited to large areas of industrial research and development but is also having a beneficial effect on the training of the four-year engineering students.

Sections and Branches

The **Kansas-Nebraska Section** of the ASEE held its annual meeting at Kansas State College, October 13 and 14. Dr. James A. McCain, President of Kansas State College, spoke at the opening dinner meeting on "Technological Trends in the Twentieth Century." Dr. McCain pointed out a scientific method of predicting what new inventions could be expected to have the greatest effect upon our civilization in the next ten years.

A panel discussion was held on the topic: "Objectives in Engineering Education, and Some Effective Methods for Realizing These Objectives with Emphasis on the Professional Orientation and the Citizenship Responsibilities of the Individual Engineering Student."

The following men were elected to office: President, K. Rose; Vice-President, J. K. Ludwickson; Secretary, J. N. Woods; Representative to General Council, D, G. Wilson.

Nuclear Engineering

By D. W. CARDWELL

Oak Ridge National Laboratory, Oak Ridge, Tennessee

EDITORS NOTE: *The following papers were presented at a Symposium on Nuclear Engineering held by the Southeastern Section of the ASEE, August 20–23, 1950.*

I think that questions which trouble engineering teachers most as they explore the atomic energy field run like this—"just what does a mechanical engineer do in this business, where does the chemical engineer fit in, and what kind of assignments do you give to your electrical engineers?" It is not easy to answer questions such as these directly because we purposely have developed a melting pot wherein we can take advantage of the important abilities and experiences of each of these professions in concentrated efforts against problems which spread across many specializations. We do find, however, that engineers of different specialized backgrounds are making the greatest contributions along lines closest to their previous training and experience. So I will do what I can to separate these for you with the hope that as you teach your conventional courses you will at least be able to provide some illustrations for your students which would give them an idea as to how they might fit into our activities.

Functions of Mechanical Engineers

Let us consider first the mechanical engineer because I believe at the present time people of this training prove to be widely useful in many branches of the atomic energy field. Our mechanical engineers are playing an important part in the design and development of nuclear reactors. We have found that the reactors built during the war merely scratch the surface and point to the interesting possibilities of a wide variety of possible machines which may be used for different purposes. Following an unfortunate period of indecision after the last war we are at last embarking upon an extensive program for the development of a number of these machines which may soon propel naval vessels, power airplanes, generate useful electric power, and produce fissionable materials and radioisotopes in large quantities. Mechanical engineers are designing and building components of reactors such as fuel elements, moderator blankets, reflectors, control rods, heat exchangers; and, an amazing array of special handling devices which can move objects in and out of the active lattice without endangering operating personnel.

Mechanical engineers wrestle with problems of fluid flow, heat exchange, and thermodynamics where new materials provide intriguing possibilities. While employing conventional design techniques they must be ever conscious of the effects of high density neutron fluxes; Alpha, Beta and Gamma radiations. Along with nuclear reactors must come extensive radiochemical processing plants. It is usually necessary to process the fissionable fuel such as uranium before it goes into the reactor and after the reaction has taken place materials are withdrawn and run through complicated separations processes in order to segregate various desirable and undesirable products. Me-

chanical engineers are busily engaged in developing pumps, valves, jets, agitators, and evaporators to fit into these chemical plants.

Much of this equipment starts according to conventional standards but must be adapted for the unusual nature of the materials flowing through the process. These materials are generally quite radioactive, highly corrosive and can not be concentrated in greater than certain maximum quantities. Engineers must take industrial indicating instruments and automatic controls and fit them into these processes so that they can be operated safely and efficiently.

A field of growing interest to the mechanical engineer involves the design and development of devices which can perform certain standard functions when separated from the operator by concrete walls several feet thick as protective shielding. At Oak Ridge National Laboratory we have just completed design of a remotely operated machine shop for a new hot laboratory where radioactive specimens will be handled in their solid state as a part of basic and applied research programs. Unusual devices are being developed which allow operators to view the activities within these cells. We have periscopes, remotely viewed miscroscopes, and windows three feet thick which are actually glass tanks filled with a very heavy solution, zinc bromide. People at the Argonne National Laboratory in Chicago have developed stereoptical television which requires a minimum of penetrations through concrete shielding walls and yet allows an operator to perform his experiments with complete depth perception on the television viewing screen. In our isotope production plant we uncap bottles, accurately pipette measured quantities of active solutions into smaller bottles, and package these for shipping to our customers. All of these operations must be handled by means of complicated remotely operated mechanical equipment.

In the field of high voltage accelerators where massive new machines are being constructed in various parts of the country mechanical engineers are playing an important roll in the design of vacuum tight tanks, carefully shaped electrodes, and unusual auxiliary mechanical equipment. Just now we are confronted with an extremely difficult problem of electrode fabrication for our Van de Graaff generator which reaches all the way from the complicated subject of electromagnetic field theory through mechanical design down to the machinists in our shops.

Electrical Engineering Problems

Electrical engineers find their principal connection with nuclear reactors in the development of automatic controls for these machines and in providing radiation measuring instruments. Before very long we may find electrical engineers playing another important role, that of producing power from generators which may be driven by nuclear powered turbines. The control of nuclear reactors is an extremely important field. Whenever we assemble an appreciable volume of fissionable material there is an accompanying hazard which if not properly recognized and handled can cause considerable damage. In order to be able to develop reactor controls our electrical engineers must learn quite a bit about reactor theory from our nuclear physicists. However, the devices which we develop are made up of conventional components which can be found in servo-mechanism gun turret control systems, radar transmitters, etc. When we feed into this control system the pile equation we must train it to react in the manner which we prescribe. To accomplish such an objective we employ motors having extremely rapid response to signal change and electronic amplifiers with feedback loops to insure stability. Such a system must then be adapted to mechanical drives for the reactor control rods.

Much of our work in the atomic energy field is dependent upon having reliable radiation measuring instruments. Certain features of our reactor operations and our chemical processes must be auto-

matically controlled by these devices. Radiation detection instruments of another type must always be handy in sounding an alarm in case radiation levels exceed human tolerance. Probably the most important use of our extremely accurate radiation instruments relates to their use in basic research. The nuclear physicists and frequently the radiochemists and the biologists obtain practically all of the intelligence from their experiments by means of radiation instruments. These instruments employ primary detectors such as ionization chambers, Geiger-Mueller counter tubes and rare crystals to produce the original electrical impulses. From here on out, however, problems in this field become problems of electronic circuitry which are familiar to the radio engineer. High speed counting circuits are used, somewhat similar to those employed in analogue computers, and wide-band amplifiers are developed which use many of the techniques that have been developed in the radar industry.

In the high voltage accelerator field, electrical engineers are depended upon to design and develop external power supplies, and many internal features of the machines themselves. Scientists are today exploring high energy levels using synchro-cyclotrons, linear accelerators, betatrons, and Van de Graaff machines which are placing requirements upon electrical engineers that are indeed challenging. Electrical power supplies have been developed which deliver thousands of volts at high currents under carefully controlled conditions. Some of these power supplies must be regulated to provide extremely smooth direct current. Others must be made to oscillate through a wide range of frequencies. Here again conventional components are put together in a fashion to meet these requirements. Our larger power supplies use vacuum tube rectifiers originally built for radio broadcast transmitters and the conductors between these power supplies and the accelerator machines employ cables made for the x-ray industry capable of withstanding the extremely high voltage involved. Insulation within the units themselves presents extremely difficult problems involving gas discharge, corona and various forms of ionization.

Chemical Processes

Our chemical engineers, as would be expected, make their major contribution in the development of chemical processing plants for handling radioactive materials. Well-known methods are adapted to our special requirements involving acid dissolvers, solvent extraction columns, evaporators, etc. Design engineers must be continually conscious that the entire process must be assembled and operated in closed concrete cells in order to confine dangerous radiation. We are in a continually never ceasing business in Oak Ridge of developing methods for separating various elements and compounds which are important to our program. Some of these elements in the range of uranium and above, on the periodic table, represent materials about which there was little known before the last war. Our chemists continually experiment with these elements and work out means in tabletop glassware scale for performing certain operations. Chemical engineers then develop flow diagrams for new processes which can be expressed in terms of pilot plants composed of stainless steel tubing, tanks, agitators, scrubbers, etc. These pilot plants are tested and operated, and improvements are developed on them before proceeding to full scale projects which may take place at one of the large atomic energy installations either at Oak Ridge or away from Oak Ridge. Our chemical engineers are playing an important part in developing facilities for the manufacture and handling of radioactive isotopes which are finding such wide spread usage throughout the country.

There are some interesting new developments in the nuclear reactor field which are making further demands upon the skills of chemical engineers. It is now thought possible to make many of the

reactor components take liquid form rather than mechanical form thereby gaining certain advantages. Chemical engineers are assisting with the development of these new ideas which should have some physical realization before long.

Civil Engineering Contributions

The civil engineering profession is making significant contributions in certain phases of the atomic energy program. We have many problems involving unusual structures where we use conventional material such as reinforced concrete and structural steel to provide mechanical stability to nuclear reactors, radio-chemical processing plants, and special research laboratories. Although much of this design proceeds according to standard handbook information it is necessary for our engineers to learn quite a bit about the special features of radioactive materials so that they can be properly accommodated. The design of a series of hot cells, made chiefly of concrete, lead, and steel represents an interesting undertaking. Here, we are not interested so much in the strength of concrete as we are in its density to provide these radiation proof walls. We are actually employing special aggregates now such as barytes which can produce a special heavy concrete which for a given thickness may provide from 50 to 100% more effective shielding than conventional concrete. The handling and placement of this heavy concrete mix provokes some unusual field construction problems and the carpentry form work involving penetrations for perioscopes and viewing windows, handling devices, etc. becomes rather complicated.

It must be remembered that various engineering materials can react quite differently in fields of Alpha, Beta, Gamma, or neutron radiations and our engineers must learn what these unusual characteristics are so that our designs may be not only effective but efficient and economical. We have, of course, employed civil engineers for conventional field surveys to initially locate and layout new projects and this is all accomplished by conventional engineering methods. Our field engineers are learning many of the unique characteristics of atomic energy work because frequently these characteristics will have an important bearing on the determination of appropriate site selection and structure orientation for a new project.

Engineering and Science

Now that we have reviewed the place of some of our more important engineering classifications in the atomic energy field we can draw one or two quick conclusions about the qualifications which are needed for this work. First of all our personnel must be well grounded in the basic training of their profession. Too often, I think, people would attempt to completely convert engineers into scientists for this work. It is true that our engineers must understand more basic science than usually required for other fields, and this is important, but they can never assume what are the proper responsibilities of the chemists, physicists, metallurgists, etc. There is a vast storehouse of knowledge and experience in the engineering profession. Our engineers must continue in close contact with this storehouse so that they can make it always readily available as an aid to scientists whose necessary specializations keep them somewhat remote and removed from this information.

In the atomic energy business there is not much room for people who are content to be simply "handbook engineers." Much of the design information which we use has never appeared in any handbook and it is doubtful that any time in the near future we will have a breathing spell in the urgency of our efforts which will allow for the preparation of complete handbooks. Also, the findings of our research people are so rapid and significant that design data useful today may be completely useless tomorrow. Frequently, training of engineers is directed toward making them capable of step-by-

step duplications of previous designs without complete knowledge of basic theory. Without a good grasp on basic theory, engineers in the atomic energy business have a difficult time, because we seldom make a chinese copy of a previous structure. Sometimes in the past we have been such slaves to "standard practice" that we cannot recognize where modifications are justified, and even demanded, to insure minimum cost and proper functioning. There are many, many examples that could be cited where failure to recognize the unique requirements of atomic energy installations have caused an immense waste of time and money. This situation could be greatly improved by educating engineers toward a better understanding of certain basic fundamentals which would enable them to properly adapt conventional engineering equipment to meet our needs.

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Programs of Oak Ridge Institute of Nuclear Studies of Interest to Engineering Faculty and Students*

By WILLIAM G. POLLARD

Executive Director, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee

Dean Ernst has reported to you on the national and regional plans of the ASEE for the development of closer and more active relations between engineering educators and the Atomic Energy Commission. As he pointed out, a number of the problems considered by the national group are already provided for in our region through the various programs for university participation in Oak Ridge facilities which have been developed by the Oak Ridge Institute of Nuclear Studies. It is my purpose to report to you briefly on the plans and programs of the Institute which are of interest to the engineering profession.

Summer Symposium on Engineering in Atomic Energy

As the final portion of the programs on nuclear engineering arranged by the ASEE as reported by Dean Ernst, the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies plan to devote their summer symposium for 1951 to the subject of Engineering in Atomic Energy. These summer symposia are a regular part of the programs of the University Relations Division of the Institute. Last year the Symposium was devoted to Modern Physics and this year to Modern Chemistry. These symposia are typical of a number of activities carried out cooperatively by the Laboratory and the Institute in the interest of scientific advancement and the utilization of the special facilities of the National Laboratory for educational purposes. Although they are intended primarily for Oak Ridge and Southern University personnel, persons from outside the region are cordially invited to attend insofar as facilities permit.

Sessions of the symposium are scheduled four mornings per week, Monday through Thursday, for two weeks. The Symposium on Engineering in Atomic Energy will be held August 27 through September 6, 1951. All afternoons and the intervening Friday and weekend will be free for informal discussion or to allow visitors to take advantage of the varied recreational factlities around Oak Ridge. This intervening period would also be available for a meeting similar to this Fontana Conference if this is desired next year. Attendance at the symposium will be without charge to the individual, although each person is expected to pay his own travelling and living expenses. The detailed program and speakers will be announced later, probably soon after the first of the year.

Research Participation Program

Another program of the University Relations Division of interest to engineering educators is the Oak Ridge Research Participation Program. This program is also conducted jointly with the Oak Ridge National Laboratory. Application for the program is made by a participating institution on behalf of members of its

* Presented before the Southeastern Section, ASEE, Fontana Village, N. C., August 20–23, 1950.

scientific or technical staff for research in fields where special facilities of Oak Ridge laboratories which are not available at the institution are required for the work. Application for the program is made through the University Relations Division of the Institute and successful applicants are employed by the laboratory in which their research is to be carried out at a salary in accord with the participant's current salary at his university. In special cases, however, an Oak Ridge Research Fellowship may be granted by the Institute in lieu of a laboratory salary. A limited number of these positions are available in the several engineering fields.

This program has become one of the most extensive of those carried out by the Institute. This summer there are seventy-eight research participants from universities of the region carrying out a great variety of research and development programs in all of the scientific fields represented by the activities of the several Oak Ridge laboratories. Any university staff member interested in the program should file an application through the Institute Councilor or the graduate school Dean. Necessary forms are available on request to the Division.

Oak Ridge Graduate Fellowships

The Oak Ridge Graduate Program has been established in order to make available to universities for their own graduate programs the unique research facilities of the Atomic Energy Commission at Oak Ridge. There are two types of Oak Ridge Graduate Fellowships available to students. One is at the master's level and is designed particularly for master's thesis work in engineering and metallurgy. The other is at the doctoral level and fellowships of this type are available in all scientific fields. In each case a requirement of the program is that each student complete all resident work at his university so that only the thesis research is performed at Oak Ridge. After completion of all course work at the university, Fellows at the master's level receive appointments for from six to nine months at Oak Ridge and those at the doctoral level for from one to two years.

Any student at the required stage of his graduate program may apply to the Institute for an Oak Ridge Graduate Fellowship through the Dean of his graduate school or other official in charge of graduate studies. The stipends carried by these fellowships range from $1,500 to $2,700, and are determined by the level of the Fellows' training and number of their dependents. Every attempt is made to arrange a program that can be acceptable to any student who is prepared for advanced training, and on a basis entirely satisfactory to his university. Each Fellow works under the direction of a three-member graduate committee, two members of which are appointed from the Laboratory staff and the third member from the university in which the student is enrolled. Arrangements are made by the Institute under which the university member comes to Oak Ridge several times a year for meetings of the graduate committee with the student in the laboratory where his work is carried on.

At the present time there are four of these Fellows in Oak Ridge working on master's theses in Metallurgy and one working on a doctor's thesis in Chemical Engineering. It is hoped that the engineering faculties throughout the South will become familiar with this program and avail themselves of it for their students when the nature of the research interest makes this appropriate. Application forms for this program are available through the University Relations Division.

Radiological Physics Fellowship Program

The greatly expanded use of radioactive materials which has developed as a result of the atomic energy project has created urgent needs for personnel capable of developing and carrying out procedures to insure protection against radiation exposures. This need has been

a primary one within the Atomic Energy Commission installations for some time. By now it is making itself felt to an ever increasing extent in many other places such as hospitals, universities, and industries which use sizeable amounts of radioactive materials. The rapidly developing requirements of the national Civilian Defense Program makes this need even more urgent.

As one way of contributing to the severe shortage of competent personnel with specialized training in this field, the Commission has established a number of fellowships for training in this field at the first year graduate level. These fellowships are administered nationally for the Commission by the Oak Ridge Institute of Nuclear Studies. This year forty Fellows were selected and arrangements have been made for the provision of suitable academic training at two universities. Twenty of these Fellows are being sent to Vanderbilt University and the remaining twenty to the University of Rochester. Each group spends a full academic year of nine months at the university in a specially designed first year graduate curriculum in radiological physics. Following this period, the Fellows from Vanderbilt are sent to Oak Ridge National Laboratory and those from Rochester to Brookhaven National Laboratory for additional study and training. During this period some of the Fellows may be selected to carry out a master's degree thesis research project. Those so selected will have their fellowships extended for a maximum of six additional months for the purpose of completing their research. Their degree will be granted by Vanderbilt University or the University of Rochester, depending on the group to which they belong and provided the theses are acceptable.

A number of the applicants for fellowships this year were engineering students. The fellowships carry stipends of $1,600 to $2,600, depending on the number of dependents in each case, and travel expense and university fees are reimbursed. Radiological Physics offers a promising career to students with an interest in this type of work. Electrical engineering graduates in particular are likely to find it an attractive field in which to work, and will in general possess an adequate undergraduate background for this program. Further information concerning this program can be obtained by writing to the University Relations Division of the Institute.

Traveling Lecture Program

A final activity of interest to engineering schools is the traveling lecture program. The Institute schedules scientific lectures to be given by the research staffs of the Oak Ridge laboratories and of the Institute itself, without expense to the universities. A regular circuit of lecturers is in operation from Oak Ridge to the various universities and research centers in the South. A list of subjects available this season and forms on which to request particular lectures may be obtained from the University Relations Division.

Engineers for the Atomic Energy Industry*

By PHILIP N. POWERS

Formerly—Advisor on Scientific Personnel, U. S. Atomic Energy Commission
Now—Manpower Specialist (Scientific Personnel) National Security Resources Board

Developments in atomic energy depend upon sound engineering just as do those in any other industry. The separation between research and application seems to be shorter than ever and the need for skilled engineers to work cooperatively with scientists is correspondingly greater. Teamwork between the two can produce devices or processes which not only make use of the latest research findings, but which will also actually work.

Since the war, the proportion of engineers working on technical phases of the atomic energy program has gradually increased. Out of the 8000 or 9000 scientific and technical personnel now working for the Commission and its contractors on research and development, but not counting construction, about half are engineers. Of these, approximately 1400 are chemical engineers, 900 are electricals, 800 are mechanicals, and about 500 of the rest are civils.

Unique Problems of Nuclear Engineering

To the students and teachers in engineering colleges, questions immediately arise about what all this means to them. In planning this meeting, Dean Wessman stated clearly some of the questions in relation to education at the graduate level. He asked:

"What kind of nuclear courses should be given to engineers? Do the present courses given in most universities in nuclear physics answer the requirements for engineers? Is additional mathematics necessary? Do the engineers need a course in 'hot chemistry'? Would existing graduate courses in engineering have to be modified appreciably for nuclear engineering students? Would new specialized graduate courses be required in each field of engineering, such as a course for mechanical engineers in heat transfer problems of reactors, or a course for sanitary engineers in disposal of radioactive wastes?"

To answer these questions it is necessary to consider together actual engineering problems in atomic energy and the training engineers ordinarily receive at the present time. On the latter point, of course, none are better informed than members of ASEE. Suffice it to say, that although the training of engineers is fairly well standardized, there is, as there should be, a considerable variety and flexibility in courses offered, depending upon special interests of both students and teachers.

To go back to the first point of considering actual engineering problems in atomic energy, there are some difficulties. The security question comes up immediately and is indeed tough. But part of the reason for its toughness is that it has been exaggerated. There is a great deal of available information about engineering in the atomic energy industry, more than is generally realized. The availability of this information is known to some members of ASEE, but there are many, I suspect, who have had only limited opportunities to look into what is either non-classified or declassified.

* Presented before the Division of Graduate Studies at the Annual Meeting of the ASEE, Seattle, Washington, June 22, 1950.

It is not possible in this presentation to give much detail about what is available, but I shall quote some examples cited recently by Mr. Wilbur E. Kelley, Manager of the New York Office of the AEC. With reference to his own specialty, civil engineering, he said that in atomic energy "we're asking for buildings with heavy walls, with heavy steel plate laced into them. We ask for concrete and steel tanks that won't leak a single drop—ever. We want sewers that won't corrode—filter beds containing tiny organisms, that, in effect, eat radioactivity and thereby concentrate it for easier handling."

In the mechanical and metallurgical fields, he stated that atomic energy industry "needs designs of pumps that work at higher pressures—that will handle corrosive fluids and gases with little maintenance. We need piping that won't leak—values that are so tight that a few stray molecules will have trouble getting by. We need designs of equipment that will turn faster than the velocity of sound at extremes of high and low temperatures. We need construction materials that will be safe and strong at −450° F. and some at 4000° F. We need equipment so simple that it can be operated and maintained from behind a ten-foot wall. We may also specify that because of special nuclear requirements the structural material for one of these gadgets must be selected from three or four elements of nature—none of which has ever been used as a structural material before."

There are many other examples. With reference to chemical engineering, Mr. Kelley remarked: "We tell him that processes have to work with 99.999% efficiency. We ask for the last thousandths of an ounce of material from 30,000 gallons of solution and then tell him he can't go near the tank to see the process in action. He has to do it with mirrors! We tell him to sift the chemical gems from hot ashes and not to miss any. He has to develop ways of analyzing for one part of a material buried in a million parts of another."

The combined structural and nuclear requirements for materials are bringing into large-scale use rare metals which have been scarcely more than curiosities before. Heat exchange problems are under study which make the temperatures within engines in use today seem very moderate indeed. This could go on at length through problems of "hot" laboratories, disposal of radioactive wastes, purification of water supplies, and so on.

In all of these examples, there is obviously much rich engineering material. There are some unusual wrinkles in the problems, but basically they have to be worked out in terms of the standard fields. There are new chemical separation problems, but the process is going to depend upon chemical engineering. A high order of ingenuity is required, but fundamentals remain indispensable.

With such a variety of problems, it seems unlikely that the needs of the atomic energy industry can be met through establishment of specialized courses to deal with them separately. In the first place, it is doubtful that there will be sufficient numbers of engineers working on any particular problem to justify such training; and in the second place, it is more important that they learn the basic principles so that they may then cope with whatever problems arise. To me it seems unlikely that a special course on "Heat Transfer of Reactors" should be added, but perhaps heat transfer courses in general may be much enriched through some consideration of special reactor problems, not so much in order to train experts in reactors as to train engineers competent to deal with unusually complex heat transfer problems.

Referring back to the questions about graduate training for atomic energy work, it is clear that they can only be answered by the teachers. There is so much variety in atomic energy engineering, as well as in graduate curricula, that the best answers lie in the judgments of teachers who know the students, the

fundamentals needed for the various engineering fields, and the kinds of engineering problems in atomic energy which are important. To make these judgments, engineering faculties must of course have as intimate an acquaintance with the atomic energy industry as possible. On this basis, their collective answers to questions about courses and curricula will be far superior to any specific answers that I could offer.

ASEE–AEC Cooperative Program

But to help in making the needed information available to engineering faculties, a cooperative program between ASEE and the AEC is now getting under way. Specific ways in which such cooperation can be carried out was the subject of discussion at a recent meeting in Washington attended by AEC representatives and by the ASEE Steering Committee on Cooperation with the Atomic Energy Commission.

At this meeting the special interest of the Commission in strengthening the country's total supply of scientific and technical personnel was pointed out along with the specific need for engineers with training and experience somewhere in between the traditional fields of science and engineering.

Those present agreed that the problem of getting more declassified material, as well as recent developments never classified, into the hands of engineering faculties could best be approached through regional programs of various kinds. The Committee was assured by the AEC representatives present that cooperation on a regional basis would be both desirable and feasible. Further study is now being given to the problem by both the ASEE Committee members and the AEC staff in the regions centering about New York, Chicago, Hanford, Berkeley, and Oak Ridge.

In addition to his questions about graduate curricula, Dean Wessman inquired about this problem of getting materials into the hands of teachers. Specifically, he asked:

"Where would text books and other source material be obtained? What would be the teaching staff requirements? Could special training programs for teachers be instituted at Hanford or other centers of atomic development? Could existing trained scientists and engineers with the AEC be loaned to the university to give graduate instruction?"

These questions illustrate very well some of the matters which will be under study by ASEE and AEC representatives in each of the five regions. Depending upon local circumstances, it is likely that different answers will be found in each instance, but the over-all result will be increased availability of material and more frequent contacts between engineering faculties and the atomic energy industry.

In partial answer to Dean Wessman's questions, however, I can name several sources of information. In addition to articles published by Project scientists in the regular professional journals, the AEC operates a small plant to print, for public distribution, copies of reports suitable for dissemination, but not otherwise published. These documents are now being sold by the Document Sales Agency, Technical Information Division, Oak Ridge, Tennessee, but as of July 1, 1950, the sales operation is being transferred to the Office of Technical Services, Department of Commerce, Washington, D. C.

The Technical Information Division also issues a journal of abstracts covering the Project literature and the published literature both from foreign and domestic sources dealing with nuclear science. This journal, appropriately called *Nuclear Science Abstracts,* is issued semi-monthly and is extensively indexed. *Nuclear Science Abstracts* is also available to the public on a subscription basis from the Document Sales Agency or the Office of Technical Services. It is one of the best present day guides to nuclear information.

The compilation and publication of a comprehensive account of atomic energy developments is another service rendered. Of prime importance in this respect is

the *National Nuclear Energy Series,* a cooperative project among the contractors and the AEC for the preparation of an extensive description of many of the war-time and post-war developments of the atomic energy Project. The books in this Series are written by Project scientists, edited and composed by the AEC, and published by the McGraw-Hill Book Company under a contractual arrangement. Fourteen books in this Series have already been published. The complete series as planned will include approximately sixty books for publication.

As examples of other compilations of information developed on the Project, there is the *Trilinear Chart of Nuclear Species,* a very detailed isotope chart being published by John Wiley and Sons. A *Handbook on Aerosols* is now being published by the Commission through the Government Printing Office. This Handbook is a group of chapters selected from the Summary Technical Report of Division 10 of the National Defense Research Committee which were declassified by the Army at the request of the AEC. A book entitled, *Effects of Atomic Weapons* is now in press at the GPO, and another book, *Sourcebook on Atomic Energy* written by Dr. Samuel Glasstone will be published by a commercial publisher before the end of the calendar year.

Last, but not least, the famous *Smyth Report* remains one of the outstanding documents for explaining the basic science and indicating at the same time some of the requirements which have to be faced in atomic energy engineering.

There is still another kind of question which students and teachers raise about what atomic energy developments may mean to them. They would like to know if there are careers to be had in this new industry, and if so, how many. Specifically, how many atomic energy jobs are available for this year's graduates?

Engineering Era in Atomic Energy

Certainly, engineers may find careers in this new industry but the number of such careers cannot be stated because the industry cannot really take shape until engineers get in there and demonstrate that atomic-powered engines may be made to work. We are at that stage in the development of an industry when no one can say with certainty that the problems are going to be solved, nor can accurate estimates of expenses be made, nor can we even be certain that the present approaches to these problems are correct. A great deal depends upon whether "breeding" can be made to work or not. The theory seems to be all right, but engineers are needed to see if it is really practical to convert uranium-238, useless for power, into fissionable plutonium, and to do it in the course of a chain reaction in which the fissionable atoms will be created faster than they are split. This will be a nice trick since, in theory, while producing power the supply of uranium useful for atomic energy may be increased by a factor of 140. Obviously, such a "breeding" process would go a long way toward reducing costs of atomic power.

It occurs to me that it has not been so long since the television industry was at a similar stage. The answers were not in. There were some who felt that television never would be practical, and no one could say with assurance that it would grow to the point of providing appreciable numbers of careers for engineers. Nor could any one state how many jobs the industry was going to support. Yet engineers moved in on the problems, and an industry grew faster than even most of the enthusiasts predicted. Engineers went into it on faith, I suppose, that they could make the thing work.

Similarly, it is not possible to say how many atomic energy careers are available for engineers. For those with enthusiasm for meeting the challenges of all of these new and tough engineering problems, careers are to be had. Although at the moment the number of persons involved is certainly not large by ordinary industrial standards, it is clear that for the present and the foreseeable future the most serious limitation on progress in

building the atomic energy industry is manpower. Engineers with enough training in fundamentals to take over from the physicists and chemists and to bridge the gap between theory and practice are urgently needed.

In an attempt to reduce this limitation, the Commission has recently established a School of Reactor Technology at Oak Ridge. In an interim session starting last March it provided special training for engineers already assigned to projects on reactor development. Although much of their training has been devoted to fundamentals, they are of course able to go deeply into the classified aspects of reactor design.

To help increase the supply of engineers with such specialized training on a longer-term basis, the School opens formally this fall with about twenty-five recent college graduates enrolled with another twenty-five persons already employed on reactor projects. In general, the curriculum over a period of a year will include some mathematics review through differential equations, some elementary nuclear physics, followed by reactor theory, materials problems, including some solid state physics and radiation chemistry, radiological hazards, details of reactor design, and considerable laboratory work. More details on this curriculum are available, but since this is the first year of the school, it is definitely experimental.

This school represents a quick approach to the manpower limitation problem, but in the long-run, it's the job of the engineering schools to train the needed engineers. The important point is that the engineering faculties must have enough information about the present status of the atomic energy industry to determine to their own satisfaction what should be included in their courses and what new courses, if any, are needed. As they learn more about the engineering problems, they will, I believe, decide that the engineers who will contribute most will be those who understand the fundamentals of their own fields well enough to help bridge the traditional gap between the scientist and the engineer. The engineering faculties will also decide, I believe, that there is much in atomic energy engineering which can be used to strengthen and enrich the standard courses.

Sections and Branches

The **National Capital Area Section** of the Americal Society for Engineering Education held its Winter Meeting on Tuesday, February 6, 1951, The **George Washington University** serving as host. After a brief business session, Russell B. Allen, Chairman of the Section, presented the Guest Speaker, Dr. Howard L. Stier, Head of State Department of Markets, **University of Maryland,** who spoke on the subject "Improvement of Engineering Education through Faculty Evaluation Polls." Dr. Stier discussed features of what was considered a successful faculty evaluation poll conducted in the College of Agriculture at the University of Maryland and participated in by faculty, students and alumni. A very interesting and enthusiastic discussion period followed.

Henry H. Armsby, Vice-President of ASEE and Chairman of the ASEE Committee on Sections, brought greetings from the Executive Board and gave a brief cross-section of the current activities of the Board and the Section's Committee pointing toward the Annual Meeting of the Society at Michigan State College in June.

Unclassified Subject Matter in Nuclear Science and Engineering*

By M. D. PETERSON

Head, Department of Chemistry, Vanderbilt University

The fundamentals of reactor theory, involving the emission, diffusion and absorption of neutrons in various materials, are declassifiable and have been made widely available in books, journals, and Atomic Energy Commission declassified documents. While the best values of certain important nuclear constants are not disclosed, ranges or approximate values adequate for instructional purposes, but not for reactor design, are given. Thus, no school need suffer from lack of materials for teaching the basic nuclear physics. Similarly, fundamental chemistry, biology and health-protection information is declassified and readily available. Also, many of the advancements in nuclear engineering that might be of use in the laboratory or industrial practice of the country have been declassified, although, of course, integrated engineering information on the actual design and construction of reactors themselves, even small ones, remains secret.

Yet the proportion of declassifiable engineering information published is small indeed compared to that in the fundamental sciences. It is unfortunate, but true, that there has not been the incentive for engineers to write up their work for declassification that exists among the research scientists. In general, engineers within the A.E.C.'s installations and those of its contractors carry over the tendency of engineers in outside industries to keep new engineering knowledge and know-how within the confines of their own organization. And also, as in other industries, the engineers within the classified projects are very often under great pressure to meet deadlines and completion dates and cannot find time to prepare papers for publication. In this field, engineering reputations have been based on processes developed and units built, not on declassified publications.

Novel Features of Nuclear Engineering

In the atomic energy business, too, a few very competent engineers with adequate backgrounds in the fundamental sciences and special skills associated with their projects—that is, nuclear engineers—can lead many men trained only in ordinary engineering lines, yet there is still a very real shortage of nuclear engineers and of places to train them for this rapidly expanding business.

Nuclear Engineering involves many new features. Design and development engineers for piles and some processing plants must show great ingenuity and judgment in the choice of remote control equipment. Piles and "hot" Chemical processes must be operated, serviced and repaired ever afterward remotely through shielding many feet thick. An ordinarily routine engineering operation may become very difficult or be handled very differently under such conditions. The development of high-temperature power piles will also require entirely new

* Presented before the Southeastern Section, ASEE, August 28–30, 1950.

materials of construction, as the usual ones generally absorb neutrons too readily or may be damaged by radiation or corrosion. Very little has been declassified in such lines, since they apply primarily to the secret field of reactor technology, but also because there has not yet been much of the necessary knowledge developed, even of the declassifiable fundamental engineering nature that must precede technological use. The materials problems are so severe that the Commission is rushing to construct a Materials Testing Reactor at Arco to assist in their solution.

You will recall that the critical amount of enriched uranium 235 that can be made to undergo chain reaction can be smaller than 200 lbs., or smaller in size than a volley ball. Compactness for mobile nuclear power plants, and high neutron flux densities for experimental piles, and economy in many cases, all create a trend toward high power densities for reactors. The problem of heat removal from the fuel units becomes then a limiting factor, and dependable operation with heat fluxes far beyond those in present engineering practice is required. A relatively extensive heat transfer program is underway, at a number of places within and outside of the Commission's installations, and valuable additions to basic knowledge in this field are being obtained and declassified.

With increasing power density and neutron flux in reactors, the control problem also becomes more severe. For maximum safety and ease in start-up and power changes, one would like monitoring and control instruments that indicate and operate continuously, reliably, and very rapidly over the whole range of neutron flux up to greater than 10^{12} neutrons per square centimeter per second—a million milion-fold range. Instrumentation and control are also fields in which relatively extensive declassified material is available for instructional purposes and for use in other industries, and in which great advances are being made.

Chemical and Metallurgical Processes

There is also activity in chemical and metallurgical processing of special materials that must accompany any pile operations. Much of the fundamental chemistry and metallurgy of the heaviest elements (number 90 and above) has been declassified, but the technology of these materials remains a secret.

Only a small portion of the fuel in a reactor is used up before it must be discharged and re-purified, to remove the fission products which have formed in it and to recover the unused fuel for reuse. Also, any efficient pile will contain thorium 232 or uranium 238 so arranged as to absorb the extra neutrons and "breed" more fissionable fuel, uranium 233 or plutonium 239, respectively. The fission products in all of these materials make them extremely radioactive, so that remotely controlled chemical separation plants must be operated in conjunction with the piles. Also, many of the radioactive fission products themselves are separated and purified for medical and research uses, and many other materials are irradiated in the reactors to make new radioactive isotopes. These operations have led to whole new fields in "hot" chemistry and chemical engineering, in which nearly all of the separation and purification processes used in ordinary practice have been adapted for remote control operations, often in very specialized small-scale equipment made of rare materials, and often modified to give yields and purities far beyond those obtained in ordinary use. Much of this fundamental information has been declassified, but these is much more that is declassifiable and of interest to industry and educational institutions that has not yet appeared.

While I have not even mentioned many of the branches of nuclear engineering, I hope this gives you some feeling for its various problems, the very small start that has been made in this big, new field, and the range of unclassified information about it that is available for your use.

The various sources of information referred to by Dr. Roth are accessible to you all. The most complete group is the Atomic Energy Commission's declassified document series, called AECD's, consisting of a few thousand documents covering all subjects at random, but for which good indices and abstracts are prepared.

However, even the current AECD's often cover work several years old, and there is available within the Commission's installations, such as those at Oak Ridge, far more declassifiable information than has yet been released. Much of this will be of great help to you, but can only be obtained if you seek it out and expedite its declassification yourself. At least one person from each of your engineering departments should become cleared and should participate in the Commission's work at Oak Ridge for at least three months through The Oak Ridge Institute program Dr. Pollard described. Your staff member will then know what information is available and how to get it declassified. Until you can get this familiarity with the Commission's work within your own staff, it would be well for any of you that are interested to discuss the declassified material in your specialty or field of interest with one of the scientists or engineers in that field at Oak Ridge. This can be arranged through Dr. Poor of the Institute and Dr. Roth.

In these ways you may assist the declassification program in one of its aims, to release "information which is of particular value for teaching the basic theoretical principles of reactors and for describing the use of these reactors as tools for scientific research," speed up your programs for education and fundamental research in nuclear science and engineering, and thereby aid the Commission in carrying out its important work.

College Notes

Robert F. Mehl, Director of the Metals Research Laboratory and Head of the Department of Metallurgical Engineering at **Carnegie Institute of Technology**, has been named Chairman of the Metallurgical Advisory Board of the National Research Council.

Applications will be received until March 1, 1951, by the **Oak Ridge School of Reactor Technology** for enrollment in the 1951–52 session, which begins September 10, 1951. This School was established at the Oak Ridge National Laboratory in March of 1950 under sponsorship of the U. S. Atomic Energy Commission for the purpose of training engineers and scientists in the field of reactor theory and technology. A limited number of recent college graduates in chemistry, engineering, metallurgy, or physics will be accepted in the status of student-employees of the Laboratory. Other trainees, sponsored by government agencies and industrial organizations, remain on the payrolls of their home companies. Further information and application forms may be obtained from the Oak Ridge School of Reactor Technology, Post Office Box P, Oak Ridge, Tennessee.

The Undergraduate Nuclear Engineering Curriculum at North Carolina State College*

By CLIFFORD K. BECK

Head, Department of Physics, North Carolina State College

A course of study in Nuclear Engineering has been instituted at North Carolina State College. The School of Engineering of State College, in recognition of the vital role that nuclear phenomena and processes now have and increasingly will have in our society, and in discharging their responsibility to the students of the State and Nation in offering training opportunities in important engineering fields, has undertaken the task of providing a training program in this new field. The curriculum in Nuclear Engineering was organized under the direction of the Physics Department which is a member department in the School of Engineering and currently most of the specialized courses relating to the new curriculum are offered by this department. Many other departments, however, in the School of Engineering and in other divisions of the college are actively participating in the instructional program.

The program at present comprises a full undergraduate curriculum, and, also a course of study leading to the Master's Degree in Nuclear Engineering. A doctorate program is being planned, and should be completed by the time students now in lower curricula are ready for it.

Factors Influencing Decision

Several factors influenced the decision to begin this training program at N. C. State College. Among others were:

A large demand for this type of training: Our applicants come not only from (a) inexperienced students now in school and (b) from members of the armed forces, but a surprising number come from (c) experienced and generally successful persons already on Nuclear Energy projects who wish to broaden the base of their training and (d) from engineers in other fields who wish to transfer to nuclear projects. The total number of applicants is much larger than can be accepted. This broad interest became apparent quite some time before the decision was made to organize the curriculum at State College.

It is virtually a certainty that the present high demand for men with sound basic training in both engineering and nuclear technology will not decrease, but probably will increase. It is true, of course, that a tremendous industrial future for nuclear engineering is contingent on a demonstration of practical and economical power generation from nuclear sources. The demonstration certainly will be attempted, even though it will probably require 5 to 10 more years for the success or failure of the effort to be clearly conceded. The eventual success of power generation on a practical basis probably will be achieved. In the intervening years, however, the manpower total of 70,000 or so now directly engaged in one way or another in our nuclear engineering program will not decrease, even

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though military activities, now sharply increasing, had remained constant.

Almost every major installation under the direction of the Atomic Energy Commission is actively searching for additional men with engineering experience. Beyond this, there is apparently a rapidly increasing interest in certain industries, and in industrial and other research laboratories for men with basic nuclear engineering training.

The organized educational institutions of the country can provide basic training more efficiently than any other group. Specialized training and company "know how" must be given almost any new industrial employee, whether he be an electrical or chemical engineer or a bookkeeper. But no company, no matter how large, attempts to provide routine basic training which the employee can readily obtain in established schools. Yet in Nuclear Engineering, the Atomic Energy program has been forced to provide this basic training, as needed, since no schools were equipped to do the job. Indeed, much of the essential information involved in this training could not at first be divulged to the schools. Such is no longer the case, and, in the interests of overall economy and efficiency, the established educational institutions should assume their rightful responsibility.

In addition to training of students, participation of colleges and universities in this program will provide another service which is the traditional contribution of alert professors; namely, the organization, assimilation, and presentation of available information in this new field in coordinated textbook form most suitable for reference and instructional use.

North Carolina State College was particular well suited to undertake this effort in Nuclear Engineering training. The N. C. State College Physics Department has customarily placed heavy emphasis on engineering and applied physics and, being a member of the Engineering Division, is very closely coordinoted with the other 10 engineering departments in the Division. Several of these departments, e.g., chemical, electrical, mechanical engineering, etc., are particularly strong and well-staffed. Hence, there exists for the prospective student ample opportunity for developing a strong foundation and specialization in some orthodox engineering branch, in supplementation of his nuclear technology training.

The administration of the Divisions of the College offered strong encouragement and support in the proposed Nuclear Engineering activity. As the program was being considered, the Physics Department was planning to add several new staff members. When the decision to offer Nuclear Engineering was made, therefore, new staff members were selected who would most effectively strengthen the program.

Definition of Nuclear Engineering

Having decided to initiate a training program in Nuclear Engineering, there remained the difficult tasks of defining nuclear engineering, determining the areas included, deciding how best to teach the techniques involved, and arranging a proper balance with other items necessary in an undergraduate curriculum.

A Nuclear Engineer is defined as one who engages in some activity involving or relating to nuclear processes, and in that activity is able to understand the problems involved and to exert sensible efforts toward the practical solution of the problems. The range of these activities may be extremely broad. The procurement, purification, and preparation of nuclear fuels, the design, implementation and operation of nuclear reactors, utilization of reactors for producing power or radioactive isotopes, medical, physical and industrial research and applications, are only a few of the possible activities in which a Nuclear Engineer may engage. In many activities he is hardly distinguishable from some other type of engineer or scientist. For examples, in mining uranium he is a metallurgical engineer, in providing instrumentation for a

reactor he is performing as an electronic engineer, and in the study of aircraft propulsion by nuclear power he approximates an aeronautical engineer. Yet in all these activities, the nuclear engineer must have not only the usual technology relevant to the particular processes, but also the added ability to recognize, understand and cope with the nuclear phenomena involved.

A Nuclear Engineer therefore must possess the usual engineering requisites, abilities, and attitudes and, in addition thereto have the added ability to cope with nuclear processes which he may encounter.

To be quite explicit, at least 80%, and possibly almost 90%, of the training of a Nuclear Engineer should be basic, orthodox engineering training, with the usual specialization in some standard engineering branch. The remaining 10% or 20% of a Nuclear Engineer's training, though relatively small, is very essential. It consists (1) of an intimate, practical, workable knowledge of nuclear processes and techniques and (2) a subtle difference in philosophy in approaching problems in this new field. This difference in philosophy is born out of the knowledge that remote control, shielding, "zero maintenance," "surgical cleanliness," trace impurities, radiation damage, and "health physics" are primary factors which must precede, though not eliminate or invalidate, the usual engineering considerations in approaching problems to be solved.

The wide scope of activities practiced by Nuclear Engineers may be grouped into two large divisions and a few minor ones. The first major division relates to all types of processes in which the intrinsic characteristic of radioactivity itself is the factor of principal importance. Tracer technology, radiochemistry, and industrial applications of radioactivity in general characterize this type of process. Note here, as in many other similar situations, that much applied engineering practice is involved, though a particular project may be a "pure" research undertaking.

The second major division involves processes which utilize radioactivity and nuclear reactions as a means of producing other processes of primary interest. Nuclear reactors, used as means of producing radioactive isotopes, useful power, and beams of radiation for research purposes, and all the technology relevant thereto, comprise the chief part of this division of Nuclear Engineering.

General Fields Within Nuclear Engineering

The general fields of nuclear engineering include:

1. Tracer Technology
   a. Chemical Processes
   b. Bio-medical Tagged Atom Applications
   c. Indutrial Uses of Radioactive Isotopes
2. Reactor Technology
   a. Research Reactors
   b. Isotope Production
   c. Power Generation
3. Miscellaneous
   a. Biophysical Application and Medical Therapy.
   b. Chemical Effects of Radiation
   c. Nuclear Physics
   d. Chemical Engineering: Waste Disposal, etc.

From the foregoing, the undergraduate nuclear engineering curriculum must satisfy two criteria; and there is a third, as yet unmentioned:

1. It must provide basic training in nuclear technology at least broad enough to include essential information in both Radioactivity and Reactor Processes.

2. It must provide adequate training in the essentials of orthodox engineering, with some degree of specialization in a chosen field.

3. There must be included a sufficient amount of cultural, educational and historical subject matter to produce at graduation as well-rounded a citizen as possible.

Curricular Content

General Basic. 26% of the curriculum is devoted to the general cultural and educational development of the student. English, history, government, economics, social studies, physical education, etc., are included in this important group of subjects.

Basic Science. 32% of the curriculum is devoted to the fundamental sciences of mathematics, chemistry, and physics. Inclusion of biology, while not required at present, is strongly recommended as an elective.

Basic Engineering. 14% of the curriculum in this third category contains fundamental engineering courses considered essential to any field of engineering. Most of these courses are above the sophomore level.

Nuclear Technology. 11% of the curriculum is allocated to the seven required courses in this category. Additional courses relating to nuclear processes are available as electives, to meet the needs of those desiring further training along particular lines.

Technical Electives. Twelve quarter courses, or 17% of the curriculum, may be selected in whatever field of secondary interest the student, with the assistance of his adviser, may choose. These elective courses may be used, for example, to develop a sound specialization in some field of engineering, to acquire proficiency in mathematics, or to develop an interest in advanced biology, chemistry, or physics.

Throughout this curriculum, large emphasis is placed on laboratory practice as a means of insuring practical knowledge of the subject matter. Eighteen of the required courses, or an average of one and one half per quarter, have associated laboratory periods

The present offering of undergraduate courses in nuclear technology is shown in Table I. Several departments in addition to Physics are adding staff members who can develop nuclear technology courses with specialization in their particular field, and a few courses are already offered by Botany, Zoology, Chemistry and Chemical Engineering.

The course of study for the Master's program consists essentially of (1) advanced courses in nuclear technology, (2) mathematics, (3) thesis research, and (4) technical electives. Here again, the electives afford opportunity for the student to develop his interest in a chosen field of science or engineering.

TABLE I

NUCLEAR TECHNOLOGY COURSES

	Qt. Hr. Credits
Physics Department	
Modern Physics	3
Nuclear Engineering	3
Nuclear Instrumentation	3
Nuclear Physics	4
Health Physics	3
Radioactive Tracer Techniques	4
Elementary Reactor Theory	3
Chemistry Department	
Micro and Tracer Chemistry	3
Radiochemical Techniques	3
Chemical Engineering Department	
Processing and Disposal of Radioactive Chemicals	3
Zoology Department	
Biological and Chemical Effects of Radiation	3
Botany Department	
Medical and Biological Applications of Tracers	3

Subject matter for a few of the courses is available in fairly well organized textbooks already published. These texts will be supplemented by material from declassified documents and articles in the current literature. For other courses, e.g. health physics, there is no satisfactory published text material. There is available, however, plenty of information, in fact all essential information, though unorganized and uncoordinated, to form the basis of quite thorough and complete courses. In these cases the instructor must assemble and organize the material and guide the students in their usage of heterogenous sources of information to a larger extent that would be necessary in orthdox courses. This situa-

tion may perhaps afford incidental training of considerable value, since these courses occur toward the end of the undergraduate career when the student should have sufficient maturity to profit by this type of instruction.

This new training program in Nuclear Engineering will be launched in September of this year. The induction of the sixty accepted student candidates, and the arrival on the campus of most of the staff members who will teach these courses, will coincide with the initial offering of this proposed sequence of courses. As students, faculty and courses begin to mix, we are certain to find many changes and adjustments in the curriculum necessary. Our hope is that we may be able to so adjust and adapt the training program that out of it will come men with sound balance as citizens and sound judgment as engineers. We hope they will have a thorough technical training, practically adaptable to the tasks they will find to do. We hope that they will in some measure help us achieve those vast potential blessings inherent in atomic and nuclear processes.

Summer School Humanistic Social Division June 21-23, 1951

The Humanistic-Social Division of the ASEE is now making plans for its summer school to be held at Michigan State College in June immediately preceding the regular meetings of the Society. The summer school will be held June 21, 22, and 23rd, and the Divisional meetings of the regular session will be on June 25 and 26. Anyone interested, therefore, can attend both the summer session and the regular Division meetings in a period of six days.

The past two summer schools have been devoted to consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering. All of those who have attended have felt that this interchange of ideas and discussion of common problems has been well worth while, and it is hoped that this year's session will be as valuable as the past two have been.

All members of the Society are cordially invited to attend any or all of the summer school sessions and to participate in the discussions. Anyone who is interested in attending or who has a problem he would like to present is urged to write to Dr. John W. Shirley, North Carolina State College, Raleigh, North Carolina. Further information will be published in the JOURNAL as soon as it is available.

Structural Engineering as a Profession*

By OLIVER G. JULIAN

Chief Structural Engineer, Jackson & Moreland, Consulting Engineers, Boston, Mass.

If some of the statements I am about to make sound dogmatic and categorical, I apologize in advance. Your time and my patience do not permit the inclusion of numerous qualifying clauses as expressions of doubt. As a matter of fact, except for high taxes and perhaps Decartes' *Cogito ergo sum*, I am sure of nothing.

Reading of the history of structural engineering since Euler's time indicates strongly that it is truly a learned profession, demanding a rigorous and liberal educational preparation. New fields, such as relaxation methods, welding and rheology (including soil mechanics), to mention but three of many developed within the span of my memory, show that it is imperative that such educational preparation be continuous throughout one's professional life.

The Culture of an Engineer

Engineering courses leading to a degree might well be preceded by courses in liberal arts, general science and the humanities, at college level, somewhat comparable to premedical courses. Such courses should include:

1) Language, especially the art of using correct, clear and concise English and also including freehand and mechanical drawing. Drawing is a method of conveying ideas and, therefore, can properly be included under the heading language.

2) Logic, the art and science of correct reasoning, including mathematics which can be defined in two words as symbolic logic.

3) Physics, including chemistry and other allied branches of science.

4) Economics, including the mathematics of finance and the application of such fundamental laws as that of supply and demand.

5) General culture. It will be recalled that the mathematician and philosopher A. N. Whitehead said "Culture is activity of thought and receptiveness to beauty and human feeling." Accepting this as a definition, culture can be said to include politics—the relation of human beings to one another. The term "receptiveness to beauty" includes appreciation of an elegant piece of logic and the orderly and efficient planning of work, as well as aesthetics as applied to architecture and the fine arts. Activity of thought is surely a prerequisite of all professional people.

Looking back over my own experience and having in mind my observation of others, I now (forty years after graduation) believe that time spent on such study during formative years will later pay a structural (or other) engineer large dividends. However, the idea may be difficult to sell to impetuous and impatient youth. The youngsters are all too anxious to go to work on the superstructure before building an adequate foundation. It is the duty and prerogative of their teachers and leaders (in and out of school) to curb the students' natural desire to climb the heights of special-

* Presented at the meeting of the New England Section of the American Society for Engineering Education at the University of New Hampshire, October 14, 1950.

ized knowledge more rapidly than they can build a sound structure of general understanding beneath them.

Technical Competence

Having acquired a good foundation in the five categories mentioned above, the acquisition of competence in specialized fields required of structural engineers, such as:

1) Applied mechanics, including kinetics, statics, elasticity, rheology and hydraulics;
2) Metallurgy, soil, concrete, and other technologies pertaining to the properties of materials;
3) The theory of framed structures;
4) The ability to handle men;
5) The efficient handling of monies;

should be a comparatively simple matter, provided the student has a natural aptitude for engineering and is willing to apply himself diligently over a period of years.

A parrot can be trained to recite mathematical formulae, but that won't make him a mathematician—one who creates new methods in mathematics. Likewise, a young man can be trained in structural traditions, codes and building regulations, he can be further trained to prepare design drawings, copy or rearrange specifications, substitute numbers in formulae, and operate a slide rule with dexterity; all this without exercising real thought and without acquiring the educational background he should have as a professional structural engineer. To qualify as such, he should be thoroughly grounded in the basic sciences and the humanities and be able to think for himself. He should be able to reason out problems from bare fundamentals. There is a vast difference between training and education. In short, he should be so educated that he can readily acquire competence in fields which were perhaps unknown, or at least undeveloped, during the time of his formal education and in which he therefore could not be specifically trained at that time; furthermore, he should be prepared to show that the product of his work is practical, stable, and economic. A structural craftsman such as a draftsman or laboratory assistant can be trained. A structural engineer must also be educated. A craftsman has a trade, his job is subprofessional; whereas an engineer has a profession.

Before acquiring status as a structural engineer, the new graduate must serve some time as a subprofessional in a design office and as a surveyor or inspector on construction work. Under language, I mentioned drawing as part of an engineer's fundamental training. I wish to emphasize especially the importance of every embryo structural engineer being a competent draftsman when he steps out of college. This because he will probably start his career at a drafting table, and his advancement will depend largely on his ability to produce accurate and workmanlike drawings in competition with men from trade schools who have had the benefit of considerable training in the technique of drafting. Ordinarily, the college trained engineer soon outdistances his competitor from the trade school, but to start he is all left thumbs as a draftsman. This, however, is not true of the graduate architect. In this connection, the engineering schools might well take a tip from the schools of architecture. The ability to draw is as essential to the young engineer as it is to the young architect, or as the ability to apply a bandage is to a doctor. It appears essential that all graduate engineers leave their schools technically equipped at least to begin their profession and earn a living wage. Such competence includes, among other things, the ability to produce accurate design drawings, in a workmanlike and efficient manner.

Further regarding language, the ability to speak and write something approaching the King's English, to organize one's thoughts and express them cogently, clearly, and concisely is obviously a great advantage to anyone. It is especialy important for the engineer who is called on

to prepare specifications, write reports and "sell" ideas. I have repeatedly noted that the engineer who has the ability of skillfully using English advances at a much more rapid rate than his less cultured brother of perhaps greater purely technical ability. Also, the ability to think through and express mathematical formulae in words (as well as in symbols) often leads to a better understanding. For example, the words—"The curvature due to flexure varies directly as the applied moment and inversely as the flexual rigidity"—at once reveal that this fundamental law of flexure is contained in Ohm's law in generalized form —"Effect is directly proportional to effort and inversely proportional to impedance"—and give one a common sense view of the law of flexure. Such common sense views are all too often neglected; we, at times, allow ourselves to become so involved in, and perhaps hypnotized by, purely formal processes that we lose sight of the over-all picture. This may be the result of cramming too much rich mental food without allowing adequate time for digestion.

Mathematics and Common Sense

I thoroughly agree with Professor Hardy Cross [1] that "Mathematics, at least as generally (ordinarily) used, is a mechanical brain." (A substitute for thought.) However, such a concept ill befits professional men. Cross's own work leaves no doubt that he does not so use mathematics. According to Professor E. T. Bell,[2] "In its most powerful form, deductive reasoning is mathematics." I wonder if, in educating professional men, we should not get away from the idea of using mathematics as a mechanical brain. Is it not practical, more generally, to teach mathematics as a branch of logic (the art and science of correct reasoning) rather than as a substitute for thought? The close examination of definitions and premises, the scrutiny of meaning at all stages of an argument, and the appreciation of range of application are far more essential than purely formal skill in mathematical processes. No matter how involved or elegant the argument, the conclusions (except by accident) can be no better than the basic data. In fact, the more involved the calculations, the more need for an over-all common sense check. We all know that, if the argument leads to contradiction of the basic law of statics or the principle regarding conservation of energy, the conclusion is in error. Such checks should always be applied.

To teach mathematics as a branch of logic probably requires far more time and mental effort by both the teacher and the student than, in general, is presently devoted to this important subject in engineering schools. The requisite time for digestion—thinking things over at one's leisure—is far from negligible. Modern engineering makes such large demands over such a broad and ever-increasing field of what is commonly known as higher mathematics that I believe courses in pure and applied mathematics should extend over the student's entire academic career and that a graduate engineer should continue to study and use these subjects throughout his professional life. What proportion of our graduate engineers can and will use calculus and differential equations or probability? They all should.

Economic Results

All structural engineers of professional status should be capable of thinking in terms of economic results. Owners who employ engineers, being business men, always do. As a matter of fact, a professional engineer is essentially an economist. A structure, be it a bridge, tunnel, dam, power plant, factory or office building, should earn a fair return on the invested capital. The determination of which of several schemes is the

[1] "Technology and Education for Engineers," *The Yale Scientific Magazine*, April 1946.

[2] "Development of Mathematics," 1st edition (1940). McGraw-Hill Book Company, p. 546.

better economic solution and what portion of a given development should be built at a given time in order to produce economic results is as much a part of an engineering problem as is the determination of the structural stability of the work. Such problems require a working knowledge of at least statistics, probability, cost keeping, cost of funds, depreciation, obsolescence, amortization, property taxes, annuities, present worth, and earning power. Of course, considerable uncertainty is inherent in all economic comparisons. Like problems in applied mechanics, the conclusions can be no more accurate than the assumptions and premises on which the argument is based. However, in either case we can use as many sets of reasonable assumptions as are necessary to bracket the range of uncertainty and derive corresponding conclusions on which to judge the relative economics, or safety of the structure. In both cases, unique solutions exist only in over simplified cases which have no counterpart in reality.

In the last analysis the professional engineer, like the business man or other professional, must rely on judgment. Common sense can and should be aided by the application of scientific methods, but it can never be entirely supplanted by such methods.

In the catalogue of subjects pertaining to mathematics of finance given a moment ago I mentioned statistics and probability. In his recent prize winning paper entitled "Safety of Structures" Professor A. M. Freudenthal [3] has demonstrated that these subjects are also most important in estimating the relative safety of structures. Surely an owner has the right to ask his engineer the following listed questions regarding a structure designed or reviewed by that engineer:

(1) What superimposed overload will the structure probably withstand without causing collapses?
(2) What superimposed overload will it probably withstand without impairing its usefulness?
(3) What is the probability of failure?
(4) What is the probability of its becoming unserviceable?
(5) What is its probable useful life?

I wonder how many practicing professional engineers can give cogent and concise answers to these questions within a range of reasonable accuracy. We are only now beginning to develop rational methods for:

(1) Estimating the probable resistance of a structure.
(2) Estimating the probable loadings to which a structure will be subjected.
(3) Correlating the resistance and the loading so as to insure reasonable serviceability and safety without sacrificing economy.

Here is a large field for development in structural engineering.

I have sometimes heard it said that a member of the profession who has become largely concerned with executive and managerial duties, rather than with purely technical details, such as strength and deflections, is no longer practicing engineering. One might as well say that a general engaged is directing troops is no longer a soldier. Such jobs require a broad viewpoint, including understanding of the relation of human beings to one another—humane engineering—understanding which is acquired largely unconsciously through experience, study of the humanities and cogitation. It is largely the ability to handle executive, managerial, and general business matters in addition to having technical competence which distinguishes the professional man from the technician and craftsman.

In conclusion—traits of character, such as following the Golden Rule, which in itself comprises a code of ethics, the willingness to think and work hard, without regard to hours, are prime requisites of any professional man.

[3] *Transactions ASCE*, Vol. 112 (1947), p. 125 *et seq.*

Metallurgy in the Mechanical Engineering Curriculum*

By RICHARD F. EISENBERG

Assistant Professor of Metallurgy, University of Rochester

Next to the metallurgist, the mechanical engineer probably has the greatest need for knowledge of metals. The need for this knowledge is evident, and in recent years more and more emphasis has been attached to its importance. Industrialists and educators alike are in agreement that mechanical engineers need a strong background in metallurgy. But are we doing the most effective job in our engineering colleges? Are we giving our engineers enough metallurgy, and is it of such a nature that it will equip them to do the best work for themselves as well as for their employers?

It is true that all mechanical engineering curricula contain some course work in metallurgy. In general, however, the nature and extent of the metallurgy requirement is inadequate. In most curricula the metallurgical instruction is contained in a three hour lecture course in "Engineering Materials," which is meant to cover such topics as: cement, concrete, fuels, plastics, wood, as well as the entire field of metallurgy. The best that can be expected in such a diversified course is a general and superficial treatment of each of the topics considered. There is little possibility, in this type of course, of giving the student an understanding of the basic nature of the materials. Consider only the field of metallurgy. It is, in itself, a widely diversified field. Generally, it is divided into two branches: chemical metallurgy, which involves the extraction of metals from their ores; and physical metallurgy, which involves that vast field of the adaptation of metals to use. Each of the branches can then, of course, be subdivided into ferrous and non-ferrous metallurgy. It is the branch called physical metallurgy which is of the greatest concern to the mechanical engineers. If the three hour course in engineering materials were devoted to this topic alone, it would be inadequate.

The three hour course would be inadequate because metallurgy as a science is relatively new, and since it got a late start there is still considerable basic knowledge that must yet be thoroughly investigated. Great progress has been made in metallurgical thinking in the past 50 years. The theoretical thinking as well as the practical thinking has expanded greatly, and with the many basic problems yet unsolved there is every reason to believe that this development is going to continue at a rapid rate. Much of the knowledge at hand at the present time is in the category of an art rather than of a science. If the mechanical engineer is to be well versed in his most important tool—metals—then he must be given training that will equip him to keep abreast of the changes as knowledge leaves the category of an art and becomes a science. The teaching of strength of materials, physical and mechanical properties, heat treatment, composition of alloys and good handbook technique will not accomplish this purpose. A basic

* Presented at the Annual Meeting of Upper New York State Section of ASEE, The University of Buffalo, October 14, 1950.

understanding of metals is required. A good basic course will give the student the understanding of the behavior of metals, which is necessary to prepare him for further learning. In addition, this basic knowledge will give greater meaning to his study of heat treatments, mechanical working, mechanical and physical properties and composition of alloys.

It is believed that this training can be satisfactorily accomplished in two three hour courses, provided the time is devoted solely to the teaching of metallurgy. Instruction would be principally in physical metallurgy; chemical metallurgy need only be touched lightly. The first of these courses would be a lecture course in the "principles of physical metallurgy" covering the following general topics:

Solidification and atomic structure
Crystal properties
Physical properties
Mechanical properties and deformation
Structure of alloys and constitution diagrams
Equilibrium and non-equilibrium reactions in solids.

The treatment of these topics should be strictly basic in nature.

This basic course would be followed by a course in applied physical metallurgy, consisting of two lectures and one laboratory. In this course there should be a "tie-in" of the fundamental knowledge with the practical knowledge, and also certain phases of the basic information should be verified.

It is not expected that such a program can qualify graduate mechanical engineers to compete with graduate metallurgists, but it will give them training that will equip them to face new problems in the field. It will also give them a better understanding of the old problems.

The above programs should be compulsory for every mechanical engineer, and in addition he should be afforded the opportunity to take additional and more advanced courses as his electives. In all courses offered, however, the basic knowledge should always be kept to the front, the practical knowledge will come with experience.

What Are the Problems in the Field of Industrial Engineering?*

By H. RUSSELL BEATTY

Professor and Head of Department of Administrative Engineering, Pratt Institute

The problems encountered by the industrial engineer in practicing his profession may be classified into four groups, namely:

1. Economic
2. Control
3. Technical
4. Human Relations

The economic, control, and technical problems can be solved by combining a thorough knowledge of the principles of industrial engineering with the application of the scientific method to such problems, but the fourth and probably most important group of problems to be met is that associated with the human relations aspects of the position. It is in this latter area that the real art of leadership is required, and those who fail in this respect are limited in their progress. Let us discuss each of these groups of problems in turn.

Economic Problems

The industrial engineer is constantly choosing between alternatives. He must decide whether this process or another should be adopted, this machine or another, this tool or another. These choices are made on the basis of economic considerations. Under the conditions prevailing at a given time, there is one method that will result in the lowest total cost and it is this method that the industrial engineer seeks. He cannot spend more money finding the method than he can save with it, so judgment must be used regarding the amount of investigation warranted by the economic conditions surrounding the problem. In addition to engineering economy principles, and a thorough process knowledge, the industrial engineer needs economic judgment to help him to decide when he has carried his economic analysis to the point where action rather than more analysis is indicated.

The economic problems most frequently faced are:

A. Economic selection of plant and equipment. This includes size as as well as process and equipment planning.
B. Economics of manufacture. This includes methods, tools, labor specifications, limits and tolerances on dimensions, and the like.
C. Economics of materials. This includes determination of manufacturing lot sizes and economic ordering quantities. Inventory turnover studies and the economics associated with materials handling and storage are also included.
D. Depreciation determination. This includes using adequate judgment regarding the long term economic factors involved in spite of the Federal Income Tax handicaps now prevalent.

An industrial engineer should make it a habit to apply engineering economy principles to problems of operation

* Presented at the Annual Meeting of the Industrial Engineering Division, ASEE, at Seattle, Washington, June 18, 1950.

wherever he must choose between two or more alternatives. This practice will act as an aid to his judgment. It will not take the place of good judgment, but will help to make judgment better.

Control Problems

Industrial engineers are continually faced with problems of control. How can a system be set up so that there are rules for recurring situations (policies) and only the exceptions brought to the attention of the executives for action?

Problems of this type are solved by designing systems for control that will result in obtaining the purposes, objectives and goals for which the enterprise was established. Control systems should contain plans for reaching the objectives. These plans are released by issuing orders. The actual results are then compared with those planned by continually observing, inspecting, and recording progress.

The following are some of the control problems faced by industrial engineers:

A. Production Control
B. Inventory Control
C. Quality Control
D. Cost Control through:
    1. Budgets
    2. Work Measurement
    3. Materials Control
    4. Cost Accounting
E. Wage and Salary Controls

The establishment of standards of performance and the measurement of the actual performance of each division of the enterprise against the established standards are important parts of the industrial engineer's duties.

Technical Problems

Industrial engineers meet a variety of technical problems which require engineering knowledge for their solution. Sometimes the problems are simple, such as the air conditioning of an instrument assembly area, but frequently they are very complex including the complete layout of plant and processes for the economic manufacture of one or more products.

A plant is a big machine through which raw materials pass to be converted into finished products through the efforts of men and mechanization. The design of plants of this type including the plant and process layout and construction, are technical problems requiring the best engineering talents procurable.

The following are some of the technical problems faced by industrial engineers:

A. Plant and Process Design and Construction
B. Methods Analysis and Specification
C. Tool Engineering
D. Work Simplification
E. Time Study
F. Maintenance Engineering including buildings, machinery and equipment, utilities, power plant
G. Safety Engineering

Human Relations Problems

Industrial engineering is a staff or advisory function, and those performing this function are often subject to considerable criticism from those in line positions, and vice versa. Frequently, where the human relations problems have been mishandled, there is antagonism between the industrial engineers and other members of the organization. The reasons for this are apparent, for industrial engineers are continually upsetting the status quo, and this causes dissension unless it is handled with due regard to the feelings of those affected. Therefore human relations problems are among the most important with which the industrial engineer must deal. These problems are caused by the following:

1. Industrial engineers are individuals who change things. They change methods, plant layouts, standards of performance, systems, standard procedures, etc. They are continually on the lookout for new and improved ways of doing things. But each time a change is made, the habits of people are changed. People do

not like to change their habits, to learn new things, particularly if the changes are sudden. So industrial engineers, to be successful, must learn to adjust the workers and supervisors to the changes about to take place by frequently discussing the changes with those affected. This conditioning helps the individuals to adjust to the new problems which they must face, and when the changes are actually made, there is less friction.

Industrial engineers "short circuit" the line and communicate weaknesses of individual members of the line up the ladder to top management. They disturb the filtering process by which those things which are not complimentary are removed from the communications as they are sent up the ladder. The boss gets only the things he likes to hear from his subordinates, but the staff reports disturbing things up the line. Supervisors do not like this observation of their performance and often are antagonistic to industrial engineers for this reason. To avoid this, industrial engineers frequently point out the errors or omissions to the line and refrain from reporting it up the line until it is apparent that the line cannot get the desired results. Often the real difficulty is caused by the failure of the industrial engineer to win the cooperation of the line by his intellectual and technical leadership ability.

Industrial engineers establish measures of performance, and set up control devices by which results that deviate from the standards of performance are reported up the line. This constant checking on performance often causes antagonism in spite of the fact that once installed it is impersonal and factual. Those affected remember conditions as they were before the controls were established and blame those responsible for their installation for the increased supervision that results.

The industrial engineer must approach the Human Relations Problem with a good deal of understanding of his fellow worker and his reactions, and continually strive to help him to adjust. He must be patient and understanding while men are making adjustments. He must help to train them in the new methods and explain the need for new points of view regarding controls, supervision, and the like. If he is to be successful, he must follow the Golden Rule of doing unto others as he would have them do unto him. Only in this way will be accomplish the desired results, and maintain the good will of his industrial associates.

To sum up: The industrial engineer faces four classes of problems as follows:

1. Economic
2. Control
3. Technical
4. Human Relations

It is this last one that makes his work so different from that of the mechanical engineer. The design of a machine calls for solution of technical, economic, and control problems, but the number of human relations problems involved is in the minority. The industrial engineer, in designing a plant and its organization which is composed of hundreds of human beings, must devote much more of his time to the solution of human relations problems.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 15, 1951 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of General and Regional Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

The Employment Opportunities in Small Industries for Engineers*

By A. R. HELLWARTH

Assistant to the Employment Manager, Detroit Edison Company, Detroit, Michigan

When the Relations with Industry Division had its first meeting for the 1949–50 school year, everyone was concerned about the prospects for jobs for the 50,000 graduates during that year. The Division, along with many other engineers and educators, believed that a good market for some of the 1950 graduates was in the many small industries in our country. The Division prepared a brochure on the subject entitled "Engineers Offer New Frontiers." 25,000 copies were distributed by our engineering colleges to the companies in their respective areas.

Reports at the Seattle meeting indicated the outlook had improved—a number of schools reporting that 60 to 80 per cent of their students had jobs before graduation. Then the entire employment situation was changed by the new international developments. By late fall, any graduate who wanted to go to work had a job and the talk switched abruptly to a possible shortage in the near future, in view of the alarmingly small Freshman, Sophomore, and Junior enrollments.

Undoubtedly many of the recent graduates are at work in small industries around the country and as they prove their value to their employers, the demand for others will increase. The possibilities of developing further this field of employment are well presented in Dean C. J. Freund's address on "Partnership With Industry" (*A.S.E.E. Journal*, May, 1949).

What is Small Industry?

An understanding of what is meant by "small industry" might keep us all thinking of the same or similar situations. Let us keep in mind any manufacturing or service industry where the product or service is of such a nature that the application of engineering principles or the use of the engineering method in solving the day's problems would bring benefits to the business.

As to size, it does not appear that an arbitrary maximum can be established based on dollars invested in plant or gross sales, or on the number of employes. Some small industries, by their very nature, are well stocked with engineers.

Generally speaking, the industries being considered will vary in size from those with a few mechanics or technicians operating from a garage or basement at home to one with one hundred employes and a million or so dollars of sales annually. Presumably, when they get bigger than that, it has been through the benefits of engineering services.

The Potential Employers

The U. S. Department of Commerce statistics show that in 1948 there were over 300,000 manufacturing enterprises with less than 100 employes. It has been estimated that 200,000 do not have a trained and experienced engineer. It might be said that this represents that

* Presented before the ECAC at the Annual Meeting of the ASEE, Seattle, Washington, June 19–23, 1950.

many opportunities. Not all small industries, of course, can be convinced that they would benefit from employing one, but some young men with initiative and drive can sell themselves to some of these prospective employers. Several localized surveys verify that the market is there.

The opportunities in small manufacturing industries and engineering service organizations are quite obvious. Small public utilities of all kinds have opportunities similar in nature; so do mining, oil producing and refining companies, and processers of chemical products. Ownership and operation of large buildings such as offices, stores, hotels, schools, hospitals and large governmental institutions call for considerable engineering skill and services.

In addition, there must be countless opportunities in non-technical businesses, large or small, for employes with the kind of training that the engineering graduate receives. Some of these are the food, clothing, housing, transportation, printing, newspaper, and merchandising businesses. In any non-technical business there are somewhere in its operation some technical problems. Any business operating a fleet of cars or trucks needs a mechanical engineer, for example. In addition, an engineer with the right personal qualification is likely to advance into any phase of the management in such a business.

Closer scrutiny of one's home town may disclose situations of these types and others that offer opportunities for engineers that have formerly been passed up as something less than suitable for an engineer. Engineering colleges located in those states where there are fewer large industrial centers are recognizing this more and more. Dean J. H. Lampe, North Carolina State College, says in his paper on "Engineering Colleges and Industry" (*A.S.E.E. Journal,* March, 1950), "I believe that the Society has its greatest challenge and its best opportunity to serve the future young engineers by expanding its work with small industries."

What to Know About Small Industries

Some of the characteristics and factors for the student to take into account while considering employment with small industries are:

1. There are many types of industries and a large number of individual enterprises in each type. Each graduate has the opportunity to consider a prospective employer with the kind of business that would be in line with his interests and specialized education.

2. Small industries are located in every state and in small towns as well as large cities. The graduate may find more attractive situations from the standpoint of geography and a choice of living conditions than if he seeks employment with large industries. He may find opportunities right at home where friends can be of great help in the process of getting the job.

3. Many small industries are owned by an individual or several partners, or by relatives. The owners may also actively manage the business. Before employment, the engineer should investigate the ownership and management factors and what their influence might be on his future progress.

4. An engineer employed in a small company is likely to accumulate a variety of experiences over a short period of time as compared with a large organization where each employe tends to become highly specialized. He will learn a great deal about labor relations, markets, taxes, accounting and other subjects other than engineering. He will find himself in a highly competitive situation. If properly suited, he may experience rapid advancement in both responsibilities and earnings.

5. When the small employer hires a young engineer, he will expect immediate production. He isn't hiring for a job that he sees ahead ten years. Training programs and opportunities to associate daily with members of one's profession may be non-existent. If the young engineer doesn't fill the immediate needs of

the business, out he goes. The small employer may therefore prefer to hire an engineer with experience. Such experience may be attained through a few years with some related large industry. In general, probabilities of a person transferring to advantage will decrease with length of service in the large company. He either becomes a specialist there or acquires a feeling of security that he values highly.

6. Many small companies may not have plans for developing their own top executive staff, but employ people who have proved their abilities in other companies. This may at first seem to restrict one's opportunities. Actually it provides opportunities for advancement in other small companies beyond those the engineer has in his present employment.

7. Small companies may not have as well established policies and rules applying to employe and labor relations as are required in the management of a business with thousands of employes. For an example, there may be no pay for overtime work nor employe benefit plans providing insurances and pension. The relatively higher degree of security in large companies also appeals to some people, but the kind of engineer who is most likely to succeed anywhere is not deeply concerned about finding a safe job. He will establish his own security.

8. The person who has a desire to own the tools with which he works, or to have his own business some day, will find greater opportunity in small industries to develop under conditions favorable to that attainment. He may find some of his rewards in part ownership of the business for which he works.

9. While it is important that a prospective employer be in sound financial condition and able to offer good prospects for the future, there are so many factors that influence the success of any industry that it is impossible to take a look into the future. The reserves of such a business are generally low; there must be a steady output. The ability of the engineer to bring new successes to the business may determine its future as well as his own. Keep in mind that there will never be a better time of life for the young man to take the high-odd chances than now. And for the winner, the stakes are larger. If the first position doesn't work, he can then use his experience to better advantage on the next job.

Finding Employment with Small Industries

The graduate must recognize that here is a prospective employer who isn't likely to come to the campus for interviews. Besides, he may never have thought of hiring an engineer or any college graduate. The job of finding the job and selling himself rests largely with the graduate who thinks he has the qualifications for this kind of employment.

The graduate's field of specialization and interests should help in deciding on a type of industry—e.g. plastics, air conditioning, machine tools, television, automotive parts. A good ready knowledge in the field and of the prospective employer's particular business is impressive.

A good source for names of companies and information about them is the trade association for the field selected. A 1949 U. S. Department of Commerce publication entitled "National Associations of the United States" by J. Judkins gives a complete list. (Superintendent of Documents, Washington 25, D. C., $3.50.)

There are aids and sources of information that any library can help supply. Trade magazines carry advertisements by many small companies. Credit and financial rating books often supply helpful information about a company, including number of employes and nature of business. Some good references are:

(1) Sources of Business Information —Edwin T. Coman, Jr. (Prentice-Hall, 1949)
(2) Thomas' Register of American Manufacturers
(3) Poor's or Moody's—for financial information

(4) Central Stations Directory (electric utilities)—McGraw
(5) Local city directories—Polk, the telephone directory
(6) Local engineering societies or Chambers of Commerce
(7) Classified ads in newspapers

While letter writing may be a means of getting in touch with a larger number of prospective employers, it will not generally yield as favorable a result as the interview. The applicant should not write to any employer that he isn't willing to visit at his own expense.

Responsibility of the College and the Profession

The faculty, placement officers, and other members of the profession can be of considerable assistance in the matter of helping the graduate find his place and become properly oriented to employment in small industry. There need be an increased amount of contact and acquaintanceship with the owners and managers of small companies. Dean Freund in his address on Partnership with Industry says: "It is unlikely that the small employer will become interested in college graduates unless he knows an engineering college professor and thinks he is a pretty good sort of person. And the small employer will not know any college professor unless the college professor cultivates his acquaintance."

Only the right men who will succeed should be recommended for this area of employment. As young engineers succeed, there will develop rapidly a market for more. The reputation of the college and of the profession is also at stake with these employers.

The small employer needs help on how to train and what to expect in the way of progress. The profession need give him some assistance with respect to getting the young engineer off to a good start.

The young engineer who works in a small industry may have little opportunity for contacts during the work day with members of his profession. He should be encouraged to participate in professional Society activities and to take advantage of educational facilities in the community. In small cities, his opportunities for off-the-job activities may be more in service or business organizations and in his church. Proper orientation into the community is just as important as getting a good start on the job.

Conclusion

While it may not be necessary in the next decade to uncover new opportunities for engineers, the importance of this small industry field should not be underestimated by either the college or the graduate. It is a place where the engineer can be of service and many will find opportunity for full professional development and success.

The job-seeker is more likely to find suitable employment in this field if he applies the engineering method. Here is one of life's problems to define, facts to bring together, values to select and conclusions to arrive at, and then actions to plan and to carry out. With the right attitude and a brave spirit, this job of finding the right job can be interesting, educational, and one of life's treasured experiences.

Labor Relations and the Engineer

By ARTHUR STARTZ

Instructor in Humanities, Cooper Union

The art of engineering is concerned with the application of scientific knowledge to bring about greater human happiness through increased or improved production. The study of labor relations, too, is concerned with effecting greater human happiness, through the maintenance or establishment of those institutions and practices which minimize strife and hence foster production. Engineering is concerned with the inanimate aspects of production, the mechanical tools, machinery, power and plant. Labor relations deals with human beings. In our economy, it is concerned with the associations between employees and management. Increasingly, engineers are becoming concerned with the human aspects of production.

To successfully solve the engineering problems of production today, engineers find it necessary to employ scientific principles, not merely "common sense." During the past few decades, social scientists and industrial psychologists have applied scientific analysis to the field of labor relations, with startling results. Many of the "common sense" doctrines which management assumed to be true were discarded. A difficult problem resulted—the retraining of supervisors. Enlightened management groups recognized that pursuit of the old ideas would defeat their own purposes. The complete reorientation of supervisors which was necessitated proved difficult of accomplishment. Industry today looks for men who have some training in the scientific approach to labor relations.

So far, we have approached the subject from the standpoint of management. There is another aspect, important to many engineering graduates who may come to identify themselves as employees rather than management representatives. If the wide disparity between the number of engineering graduates and the number of available jobs returns, it is likely than an increasing percentage of graduates will come to identify themselves as employees. This tendency cannot be ignored.

It is to the credit of the Engineers' Joint Council, representative of the professional societies, that such matters as salary studies have been initiated, indicating an awareness of the changing situation and a dynamic approach to present-day needs. One union of engineers has maintained that college professors are often active recruiters for engineers' unions because of the overly optimistic and fallacious picture they give their classes concerning engineers' employment conditions. More prevalent, it seems to me, is the omission of adequate discussion of this problem. In face of such a statement, perhaps the colleges should reevaluate the curricula. Students should have the opportunity to attend labor relations classes led by qualified instructors. The field of labor relations is a highly specialized one. The labor relations instructor must have had graduate training in this specific field and where possible, some actual experience, and not merely an instructor burdened with another course.

Collective Bargaining

Collective bargaining is the principal institution which the democratic nations

have developed in the field of labor relations. As collective bargaining in the United States progressed, it became necessary for government to step in with regulatory legislation of varying types. These labor laws directly or indirectly affect each of us and there is much disagreement as to what form they should take. The present federal law, the Labor-Management Relations Act of 1947 (Taft-Hartley Act), has been a burning issue in recent elections and will probably continue as a subject for debate during the coming year. It is essential that engineering graduates, who will assume positions of leadership in the community, be in a position to weigh the provisions of our labor laws in an objective and intelligent manner. A group of junior and senior engineering students recently did not display such objectivity or intelligence. When asked their opinions of the Taft-Hartley Act, 90% had very definite opinions. When questioned about its provisions, the majority displayed total or fundamental ignorance.

We have been considering the broader aspects of the import of government in labor relations. Section 9b of the Taft-Hartley Act deals specifically with unionization of professional employees and Section 2 defines the term "professional employee" to include engineers. Surely engineering graduates should be thoroughly familiar with the provisions of a law that deals specifically with them.

Here, then, we may summarize the aims of the labor relations course in an engineering college:

1. The vocational aim—acquiring familiarity with important labor problems and proposals for their handling.
2. The citizenship aim—stimulating interest in and developing objective attitudes toward labor problems, labor disputes, and labor legislation.

In furtherance of the aims just mentioned, it is important that the attitudes of management and union labor toward specific controversial matters in the field of labor relations be examined. It must be emphasized that attitudes of individual unions and individual management representatives may differ from the prevailing feeling. Perhaps, then, we should speak of attitudes of "management-minded" and "union-minded" groups. Cases showing this variation in attitudes should be discussed and the reasons therefor investigated.

Two objectives must be kept in mind: (1) to ascertain what the "labor" and "management" attitudes are, and (2) to determine why these feelings exist. There are two methodologies which will best enable the attainment of these objectives: (1) the case method, (2) guest speakers from the ranks of management and labor. In a two-semester course, both can be used in a complementary way. There is no better way to comprehend these attitudes and the reasons therefor than by discussing cases and by listening to union and management leaders present their views. The lecture method is more likely to result in memorization than in understanding.

At the outset of the course, it is extremely important that the student group and the instructor work out a modus operandi, which will include: defining the problem, obtaining and evaluating data, recognizing insufficiencies of information, arriving at conclusions where possible. However, there is no automatic transfer of the scientific method to labor relations. But unless the scientific method is applied, class sessions will degenerate to debate rather than analysis. Labor and management representatives are not the only ones who have developed attitudes on labor relations matters. Unless the class atmosphere allows a challenge to the preconceived ideas of the group itself, little will be accomplished.

Labor and Management Views

To be more specific, what are some of the conflicting attitudes of "labor-minded" and "management-minded" representatives? It may be well to briefly list a few typical opposing responses.

The Institution	Management Response	Labor Response
Closed shop	Labor monopoly. Undemocratic. Foreign to "American Way."	Strong and effective unionism. No "free-riders," each should share in costs of benefits of unionism. Union security.
Scientific management	Efficiency in production. Lower costs and prices.	Speed-up system. Lower wage rates.
Machinery	Efficiency in production. Lower costs and prices.	Unemployment. Lower wage rates.

If the modus operandi outlined above is followed in studying these attitudes, students will undoubtedly turn to the historical background as one important source of relevant data. A broad knowledge of labor history, studied in a purposeful manner, will prove a valuable asset in understanding attitudes, institutions and trends. A few historical facts will be briefly mentioned, in skeletal form, to illustrate with particular reference to the institutions and attitudes just outlined. The purpose here, of course, is solely to illustrate the importance of relevant historical facts, not to weigh the pros and cons of opposing attitudes. Two examples follow.

(1) The closed shop was an important technique of early trade unions in America, employed by craft unions in the 1790's.

(2) Both scientific management and machinery have resulted in greater productive efficiency, lower costs and higher living planes. This is measurable. On the other hand, historical evidence shows that speed-ups have frequently resulted from time and motion studies and that the unplanned introduction of machinery has created important immediate problems of unemployment.

Historical data are valuable in tracing the origin and development of institutions and attitudes. They are used, too, in redefining the issues, e.g.—labor union opposition to the introduction of machinery being replaced by demands for protection against unemployment when machines are introduced.

It has been said that the study of labor relations is the study of human relations in industry. This does not mean that the labor relations course should concern itself solely with the relations between the individual employee and management. In fact, personnel departments in some of our large industries are still making this error. The fundamental relationship between workers and management today is between union and management representatives, and sometimes between groups of unions and groups of management representatives. Defining the employment relationship is now accomplished through collective bargaining in industries with which engineers are connected, and the individual bargain has yielded to the collective bargain. Union desires often necessarily differ from those of an individual employee. Under such conditions, where management attempts to satisfy the individual demand without recognizing the importance of the union attitude, disruption in the labor-management relationship will be created. The labor relations course in an engineering college is concerned primarily with collective bargaining, the process and the agreement.

Union Objectives

It is essential to study union objectives and tactics. Internal union functioning itself must be examined to get a realistic understanding of the dynamics of collective bargaining. The reverse of this

approach, too, must be applied. In order to understand management's response to the union movement or to a particular union, it is necessary to understand how management looks upon itself, what it considers to be criteria for success, what it considers to be its functions in the economy, what its intense convictions are. The changing concept of management prerogatives, an inevitable result of collective bargaining, is a subject for study by managements, unions, and students of labor relations.

The young college graduate who is thrown into industry with no study of labor relations will have difficulty in understanding many worker reactions. The engineering graduate, who has been steeped in the tradition of efficiency, will experience even greater difficulty. If he has any supervisory function, an understanding of worker reactions is indispensable. It is a common failing of young supervisors to expect routine workers to be much more zealous in their jobs than they actually are. An example may help to clarify this point. Where a merit-demerit system is employed, the supervisor may beamingly inform an employee that he has just recommended that several merits be awarded him. To the young supervisor's amazement, the worker may grumble in reply: "That's fine, but you can't eat them." If this reaction recurs on several occasions, the supervisor should begin to question how meaningful the merit system in this plant is. Why do the employees feel this way? To what degree can merits and demerits be relied upon to secure greater efficiency? Through the case method in the labor relations course, the engineering student will be psychologically predisposed to accept such reactions, in fact to predict them.

One of the important desires of the worker and his union is to obtain as great a degree of job security as possible. Workers who get the feeling that they must make the job last may slow down in combination without a word having been spoken among themselves. In a plant where efficiency has been the sole criterion in layoffs, they may insist on the extreme application of seniority. With no background for understanding, the young engineer will react emotionally and ineffectively in condemning the soldiering and seniority. He can see no reason why he cannot retain an employee who is more efficient than another with greater seniority. Of course, he may react in the opposite way if he himself is laid off in violation of the seniority principle, although it is well-known that there is much less reason for seniority in skilled than in routine work. A labor relations course will provide the background for analysis of specific problems such as these.

We have been considering a few illustrations of course content. It has been mentioned that guest speakers from the ranks of management and labor are extremely valuable in this type of course. Formalized assignments in the various aspects of the course should be supplemented by lectures given by responsible management and labor representatives. It is necessary that the students have background for the particular topic of the day prior to the presentation by the guest speaker. It goes without saying, of course, that the instructor must be well satisfied with the qualifications of the speakers invited, both professional competence and speaking ability. It is desirable that the instructor hear the labor or management representative speak prior to the invitation. Sessions of this type should be as informal as possible, conducted in seminar fashion. Speakers who might be typically invited include personnel directors, directors of training, vice-presidents in charge of labor relations, union officers, union economists, and labor arbitrators.

One final note on outside speakers in connection with another aspect of the course. Increasingly, government is assuming importance in labor-management relations. It is important to know what legislation in this field provides, how it

has been interpreted, and how the agencies which enforce the law function. Representatives of the National Labor Relations Board, State Labor Relations Boards, the Federal Mediation and Conciliation Service, State and City Mediation Commissions, and State Councils Against Discrimination in Employment have much to contribute about the functioning of government in the labor relations field.

It should be apparent that a labor relations course provides an excellent opportunity for integration of various disciplines of learning. Economics, psychology, history, sociology, law, industrial engineering—all have contributed to a basic understanding of employee-management relations. The labor-relations course, given in the senior year preferably, is a fitting bridge between the formalized learning in higher education and the dynamics of relationships which know nothing of artificial departmentalization.

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How to Read Freshman Themes*

By JAMES H. PITMAN

Chairman English Department, Newark College of Engineering

Reading themes to the best of one's ability is the greatest service an English teacher can render to his students. If I have not yet learned how to do it perfectly, at least I know how it feels to try. That feeling I shall attempt to share with you in this paper.

No other part of English teaching so much depends upon the character, personality, and experience of the individual teacher. That is why reading themes becomes so exhausting; it involves the whole person and draws upon all his resources at once. This is also precisely true of *writing*. The proper critical and corrective reading of anything written by anyone else is a process very nearly the same as the process of original composition, except that the reader is bound by many frustrating restrictions. For, in writing, one is more or less his own master; in *reading for correction*, one must keep all his originality and imagination constantly alert, yet force them to remain the bondservants of the original author. This sensation of working in chains, with every sweep of the eager red pencil checked in midair and then carefully reconsidered and reaimed, is what makes the honest reading of Freshman themes an agonizing task.

I am here tempted to digress on the subject of assigning topics for themes, for much of the ineffectiveness of our composition courses—and much of the teacher's distaste for reading the themes—stem from the lack of motivation in most theme assignments. But that subject is too large for a digression, and I will therefore assume that the themes I refer to are written on topics about which the student has considerable information and which he feels are worth writing about for the hypothetical reader—that none-too-satisfactory audience of college papers. But even the best-motivated themes, written by the most cooperative students, are not easy to read.

It is, of course, quite possible to proofread and "correct" papers with practically no mental effort if one looks only for such crudities as misspelling, faulty punctuation, erroneous diction, and a few other staple defects of that nature. In fact, such reading can be a kind of gruesome fun if you are one of those teachers who love to collect evidence of the illiteracy of the present generation. Indeed, there *is* something primevally pleasant about spearing a fish or spotting a faulty reference—about knocking a squirrel off a limb or ferreting out "undoubtly" or "enviorment." But I maintain that there is also something on the verge of subhuman in hunting without purpose and without full consciousness of the consequences—whether to the squirrel or the Freshman. I have too often noted a cruel gleam in the eye of an instructor as he slashes at student papers. To read themes sadistically is unworthy of a teacher. To read them impersonally is not to read them at all.

For, in spite of handbooks and the venerable Cody's mail-order method, there is far more to good writing than keeping all

* Presented on June 21, 1950, at a Conference of the English Division during the Annual Meeting of ASEE at the University of Washington in Seattle.

the rules. Writing is an act of creation. Its purpose is to shape chaos into cosmos and sometimes even to "give to airy nothings a local habitation and a name." No composition, whether an epic or a Freshman theme, is independent of syntax, but literature certainly reached high perfection long before spelling or commas. Under modern conditions of eye reading, these convenient conventions must be observed, but they are none the less superficial. The bones of thought structure and the flesh of living words are what we must teach our Freshmen to handle. If they learn that, grammar, spelling, and punctuation will turn out to be relatively minor problems.

Let me hasten to add, lest you think me a teacher who scorns textual accuracy, that I am a very fussy reader. My pencil scratches savagely—whether on my own manuscript or a student's—at anything which would not do the writer credit in print. That is merely automatic proofreading. But I feel no pleasure at the sight of errors. My purpose is to help the student to learn to write, and that cannot be accomplished by any number of "deletes," "l.c.'s," or even "sp's" in the margin.

The basic problem, then, is to teach Freshmen and Sophomores how to achieve inner as well as outward form. Once, long ago, I took over a Sophomore class which, under a conscientious but very conservative teacher, had learned to beat the rap. Misspellings were rare because these bright boys seldom used a word of more than two syllables. Their punctuation violated few rules because they risked few sentences of more than one clause. Their margins were put in with a ruler, and paragraphs were uniformly indented. On the surface their themes were printable literature. But of course they said very little, and what they did say was incredibly dull and pointless. It took me nearly two months, by dint of fresh and, to them, unheard-of indictments, to obtain a good many convictions of literary sin.

That semester fully convinced me that one must insist on positive virtue in writing, not merely neutral innocence. To this day I never meet a new class without remembering my battles with those smug Sophomore writers of short sentences and disjointed paragraphs.

To teach the purpose and the structure of written thought I have, like most teachers, adopted a number of rather obvious devices:

1. I insist on the writer's first deciding what sort of person the "hypothetical reader" is. Without knowing that, writing is a gamble. Therefore, I often ask my students to write down exactly what sort of reader the paper is designed for (the teacher being disregarded in his role of intermediary editor).
2. I ask the student to state what purpose is to be served by his paper.
3. I insist on some sort of outline *before the rough draft is written.* It may be very simple indeed and, if genuine, usually is. To emphasize the dynamic, creative function of such an outline I often call it "doodling," and since I myself habitually doodle out my points as I talk *ex tempore* in class, the students soon perceive the purpose of this preliminary pencil thinking.
4. All finished papers must include the rough draft upon which the fair copy is based. Thus, if I wish, I may look back and see how the composition has taken shape—and, incidentally, I never have to struggle with that monstrosity: a one-draft paper from the pen of an amateur.

Of course students fight tooth and nail against such stipulations, and year after year try the same tricks to avoid them: the impossibly elaborate outline, written from the finished product and inserted into the too-large or too-small space left in the rough draft, or a rough draft dashed off at full speed and recopied with no attempt at revision. It takes consid-

erable alertness and intuition to save them from such time-wasting dodges, but usually, when they realize that the teacher knows all the tricks, they conform and admit the usefulness of these tools.

But the usual Freshmen, even after they have learned to block out a paper and aim it purposefully, are still helpless to mold the resultant paragraphs into smooth and effective units. Their vocabulary is small, or at least lacking in precision. They have no ear for prose rhythm, no feeling for the texture of a paragraph, no conception of the wonderfully cohesive power of pronouns, little understanding of the value of subordination, and almost no sense of proportion and emphasis. When I was younger, I used to depend on "exercises" to teach these things, but I have found so little correlation between the ability to write well and the ability to fill out blanks "correctly" that I now rely mainly on detailed correction of the individual themes.

How, then, do I personally approach the reading of themes? First of all, I remind myself that the difference between a Freshman theme and the work of Thucydides, Chaucer, or Hemingway is a difference of degree, not of kind. Whether great or little, success or failure, a piece of writing is the effort of one man to communicate with others by words painfully chosen and arranged to the best of his ability. As a participant in this uniquely human activity, even a Freshman deserves respect. No matter how crude the result, his theme should be approached with kindness. He has gone through the throes of literary travail, and, like any other parent, is likely to be sensitive to criticism of his offspring. No matter how harsh I may have to be, I must always make him feel that I have respect and a fellow-feeling for him, the writer, even though I may thoroughly disapprove of his product. For, as I often tell my classes, I hate bad *writing,* but I have nothing but sympathy for the *writer.*

Retaining, therefore, a spirit of kindly fellowship, no matter how weary of themes I may be or how many previous poor grades the student may have received, I open the paper and look it over precisely as if I were an editor in need of good copy. I try first to see what the writer is aiming at, and then begin to read.

From that moment I become two persons, one hovering over the paper as the Olympian editor, the other down among the words and phrases with the struggling author himself. Even as Ego One attacks a bad sentence, Ego Two is at work trying to see how it may be repaired. Ego One objects to everything which he feels will offend the hypothetical reader, while Ego Two humbly accepts his judgment and attempts to touch up the blemish or supply the deficiency. Sometimes, however, Ego One demands the impossible. Then Ego Two remonstrates, and Ego One admits that he is being old-fashioned, pedantic, opinionated, or just plain wrong.

So habitual has this division of personality become that I have learned to produce it at will—much as one can learn to control his vision by preventing reflex interaction of focus and convergence when he wishes to view stereographic photographs without a stereoscope.

This sort of attitude, I find, makes it easy to avoid that cardinal fault of bad editors—demanding that the writer think *my* thoughts and write *my* style. It continually reminds me that a generation separates me and my student—that I write a style with the rhythm and diction of an English teacher born in 1896, which is certainly unsuitable for a boy born in 1933. It warns me to avoid automatic rejection of modernisms and automatic approval of literary phrases and handbook pedantries. And especially it forces me to think of practical solutions to the awkward situations my editorial eye objects to.

Throughout my reading of a paper I try to keep my mind firmly on the subject matter, as if I were an ordinary reader. I proofread as I go, placing appropriate marks in the margin, but I try not to let that activity disturb my atten-

tion to the ideas. Wherever I trip in reading—either because I fail to understand instantly or because I am not sure of what the author means to emphasize—I place some sort of mark—often just a check or an underline. Something must be done about this hiatus, this stumbling block, or this unintentional false clue before the copy goes to press. Just what to do is sometimes a poser, for this is someone else's work. I am not free to "rubbe and scrape" or rewrite whole sentences as I so blithely did when I was preparing the script of this paper. I must point out the trouble to the author, but merely suggest a remedy and let him do the rest. The integrity of a man's own style (even a Freshman's) is almost a fetish with me, and I do not want my student to parrot my words.

So, finally, the margin fills with marks: references to the textbook, questions about the subject matter, indications of misspelling or obviously unacceptable diction, and even, as a final resort, suggested changes couched in my own words—but these last always with a question mark, since the writer himself may well find a better solution than mine. Then, at the end, I usually write some personal comment—sometimes praise, sometimes the reverse, but always something to let the writer know that his paper has been *read,* not merely "corrected."

I have so far been talking about myself, but what about the student? Does he learn to write when his papers are read like this?

I can give only a very personal answer. In my opinion the good student often learns very quickly and even the weak one makes very appreciable progress. At first, of course, students used only to niggling correction of details find it difficult to believe that the teacher really takes their writing seriously—that he means to apply professional standards not only to the outward form but to the innermost convolutions of their thought. But I think a student seldom ends the year without improved powers of thought and expression and a firmer idea of what good writing really is. He is also less self-conscious about his writing. When he sees me, the omniscient teacher, awkwardly struggling with intractable sentences or weighing the advantages of one or another arrangement of points in a paragraph, he realizes two things: that *everyone* has trouble with writing but that, after all, most problems even of writing yield to hard work. He also learns a few of the tricks of the trade, but soon sees that good writing seldom depends upon tricks. And finally, I think, he often generates something very important in the education process: respect for his own work and respect for any teacher who regards him as a fellow craftsman and works with him rather than against him.

To be sure, all this close personal attention exhausts one's store of energy and takes time—much, much time. If I get through five or six 300-word themes in an hour I feel I am better than average that day. Eyesight deteriorates and the spirit rebels. But one thing I have gained: I can now give out semester grades with an easier conscience than I could twenty years ago. And that, I think, balances all the rest.

Exhibit of Teaching Aids at the Seattle Meeting

S. G. LUTZ

Professor and Chairman of Electrical Engineering, New York University

A report of those teaching aids exhibited at the 1950 meeting of the Society has been deliberately delayed until this date with the expectation that potential exhibitors for the 1951 meeting who were not at last year's meeting might find some encouragement in learning of what others are doing.

The third annual exhibit was held in the Guggenheim Building, University of Washington, under the sponsorship of the Committee on Teaching Aids. The exhibit was housed in five rooms with an additional room for the projection of films and slides.

One highlight of the exhibit was a simple relay type digital computer, nicknamed "Simon," which served to demonstrate the important operations of programmed digital computation. Simon was built by Robert Jensen and Andrew Vail of Columbia University under the direction of Dr. E. C. Berkeley, author of "Giant Brains" and was demonstrated by Dr. Ned Reglein. Its dimensions were about 20 inches by 14 inches by 6 inches, and it contained about 100 relays operating from orders and input data supplied from a perforated tape. Within its extremely limited capacity of 2 binary digits (decimal numbers from 1 to 4) it was able to demonstrate the most important functions of the larger and faster digital computers.

The exhibit of the U. S. Air Force Institute consisted of 40 beautifully built dynamic models for use in teaching mechanics. Also included in Professor Valey's exhibit were a few cut-away models, photographs, charts, etc.

Professor W. J. King of U.C.L.A. exhibited two selectoslide installations with synchronized magnetic recordings, and also an automatic quiz machine set up with questions concerning the California motor vehicle code. The U.C.L.A. exhibit also included a beam theory demonstrator by N. E. Friedman.

New York University exhibited a switching circuit illustrating a problem in logic, built by Professor James Ley, a rubber dam model of the potential distribution in a triode, built by Professor George Anner, two simple animated cardboard vector diagrams by Professor Lutz, the magnetic field tube built by S. Tetenbaum and the ultrasonic lantern slide control circuit built by George Rand, both under the direction of Professor Lutz, and the use of fluorescent chalk with an ultraviolet light source in classrooms darkened for projection.

Other exhibits included a PTZ and three Ternary Phase models of clever spot-welded construction by E. A. Peretti and E. E. Hoffman of Notre Dame, plastic planetary gears from Ohio University (Athens), two machine models from Montana State College, two viscosity and lubrication demonstrations from the University of California (Berkeley), as well as a cam motion demonstrator by J. Scheinman. The University of Southern California exhibited a complete working model of pipe intersections. From Idaho State, Professor H. O. Ritland exhibited a vacuum tube characteristic curve demonstrator built from a war surplus BC929Z radar indicator, while A. E. Taylor exhibited a geiger counter and samples of Idaho radioactive ores.

Because of the location of the 1950 meeting in the extreme northwest few of the eastern schools could send large exhibits, but were well represented by photographs, charts, lantern slides, films and similar items which could be sent by mail. Many of these were photographed in 35 mm. strip film in black and white and were projected with an automatic slide projector with automatic slide changing operated from a magnetic tape recorder which supplied the narration. Thus exhibitors who were not able to be present at the meeting were able to have their material shown and explained. The automatic slide projector was operated continuously and provided approximately a two hour nonrepeating show. The following individuals submitted photographic material which was presented in this fashion:

Professor Edwin B. Weinberg, Sacramento State College, Notes and Solved Problems in Physics for Engineers.

Professor G. S. Timoshenko, University of Connecticut, Details of Electrical Connectors.

Dean E. D. Howe, University of California, Cam Motion Indicator.

Mr. Grant K. Borg, University of Utah, Model of a Sewage Treatment Plant.

Dean L. K. Downing, Howard University, Various Types of Teaching Aids.

Dean W. P. Kimball, Dartmouth College, An A-C Network Calculator.

Professor John M. Hirst, Dartmouth College, An A-C Network Calculator.

Professor A. S. Hall, Purdue University, A Cam Model and a Gear Train.

Professor W. H. Glenn, Jr., John Muir College, Mathematics Models.

Professor J. B. Gribbin, Manhattan College.

Professor R. K. Bernhard, Rutgers University, Instruction Models Used in the Mechanical Vibration Laboratory.

Mr. C. G. Kahlert, Compton College, Photographs Used in Engineering Drawing.

Exhibitors whose displays were shown in the exhibit rooms included the following:

Professor R. S. Hall, Purdue University, Plastic Linkage Models.

Dean E. D. Howe, University of California, Cam Motion Indicator Model.

Dean Paul Cloke, University of Maine, Photographs and Displays of Engineering Problems.

Col. B. W. Bartlett, U. S. Military Academy, Photographs of Electrical Engineering Installations.

Professor A. D. Moore, University of Michigan, Pictures of Fluid Matter Technique.

Professor H. O. Ritland, Idaho State College, Photograph of Model Cyclotron and Devices in Electronics and Engineering Physics.

Dean E. J. Taylor, Ohio University, Lucite Models.

Dean E. W. Schilling, Montana State College, Broaching Mechanism.

Professor E. A. Peretti, University of Notre Dame, Wire Phase-Diagram Models.

Dean R. D. Landon, University of Akron, Photographs of Special Laboratory Equipment.

North Carolina College of Agriculture and Engineering, 120 2-inch by 2-inch slides of models and typical instructional slide material in the various engineering courses.

Professor F. W. Davis, and R. W. Wagner, Ohio State University 16 mm. motion picture film, "Accent on Learning."

Professor Carl W. Muhlenbruch, Northwestern University, Sound-slide film, "Lines of Force."

Professor L. R. Blakeslee, University of Detroit, Photographs and 16 mm. motion picture of building construction for architectural engineers.

It was encouraging to note that many teachers are overcoming their reluctance to exhibit what they consider to be hastily

made teaching aids and which they consider too crude to be placed on display. The annual exhibit serves as a medium for changing IDEAS for teaching aids which any one can build. It is not a trade show of devices to be purchased or of elaborate models made of polished brass and mahogany which are beyond the capacity of many college shops. Elaborate models and automatic projection devices may be entertaining but it is the simple gadgets built in a few minutes from cardboard, paper clips, and other materials that are readily available which are remembered, duplicated, and actually used in classes. The Committee on Teaching Aids hopes that more of these will be exhibited next year. Individuals interested in exhibiting at the Lansing meeting and requiring additional information may forward inquiries to Professor R. J. Jeffries, Department of Electrical Engineering, Michigan State College, East Lansing, Michigan.

ANNUAL MEETING

June 25–29, 1951

MICHIGAN STATE COLLEGE

East Lansing, Michigan

TIMELY TIPS

TIMELY TIPS is a new section in the Journal devoted to unique ways of teaching difficult concepts so that they can be easily grasped by students. Contributions to this section should constitute an improvement over current textbook presentations. They should not exceed two Journal pages in length (including illustrations). If you have novel, short-cut methods of making difficult concepts seem simple, your colleagues will be glad to see them in the Journal. Send contributions of the Editor, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.

A Simple Method of Presenting the Combined Variable-Load Equations

By R. T. HINKLE

Professor of Mechanical Engineering, Michigan State College

Many students in Machine Design have trouble with the usual presentations of variable loading. The following method has been used by the author with good results:

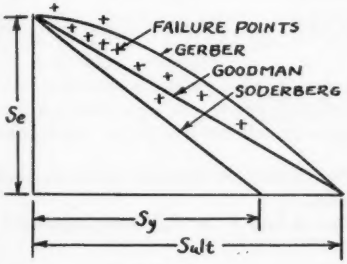

FIG 1

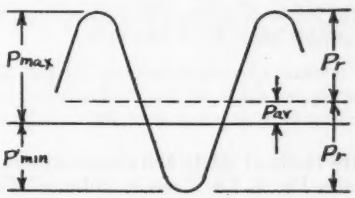

FIG 2

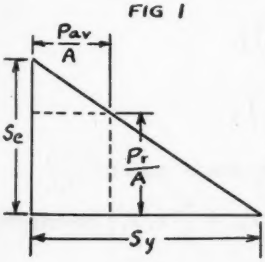

FIG 3

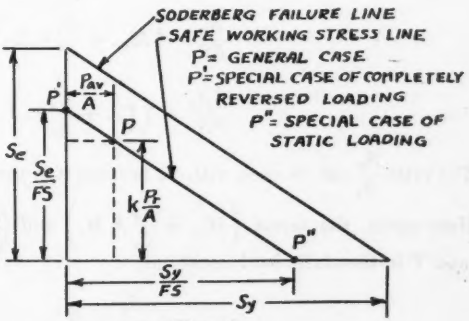

FIG 4

The Gerber, Goodman and Soderberg lines of failure are shown in Fig. 1. These are assumed lines to fit approximately the failure values that have been determined experimentally. It can be seen that the Soderberg line is on the safe side, and is consistent with the general design practice of working with the yield stress rather than the ultimate stress.

A typical type of loading is shown in Fig. 2 where the load varies from P_{max} to P_{min}. This is also shown as an equivalent static load P_{av} and a completely reversed load P_r superimposed upon it. The loading shown in Fig. 2 is also shown in Fig. 3.

From similar triangles,

$$\frac{S_y - \frac{P_{av}}{A}}{S_y} = \frac{\frac{P_r}{A}}{S_e}.$$

This equation can be written in the form

$$S_y = \frac{\left(P_{av} + \frac{S_y}{S_e} P_r\right)}{A}. \tag{1}$$

The student can obtain a physical concept of this by explaining that P_{av} is based on the yield stress and P_r is based on the endurance limit. Now if P_r is increased a certain amount it can be treated as an equivalent static load. The multiplying factor $\frac{S_y}{S_e}$ does this. It can be seen that $\left(P_{av} + \frac{S_y}{S_e} P_r\right)$ corresponds to P in the static load equation $S_y = \frac{P}{A}$.

If the factor of safety is introduced and the stress concentration factor is applied to the variable load, Eq. 1 becomes

$$\frac{S_y}{FS} = \frac{\left(P_{av} + \frac{S_y}{S_e} k P_r\right)}{A}. \tag{2}$$

If the factor of safety and stress concentration factor are included in the diagram as shown in Fig. 4, Eq. 2 can be obtained directly.

If the appropriate symbols are used in Figs. 2 and 4 the following equations for bending and torsion can be obtained:

$$\frac{S_y}{FS} = \left(M_{av} + \frac{S_y}{S_e} k M_r\right) \frac{c}{I}, \tag{3}$$

$$\frac{(S_s)_y}{FS} = \left(T_{av} + \frac{S_y}{S_e} k_t T_r\right) \frac{c}{J}. \tag{4}$$

The ratio $\frac{S_y}{S_e}$ can be used with T_r because it is very nearly equal to $\frac{(S_s)_y}{(S_s)_e}$.

Here again, the terms $\left(M_{av} + \frac{S_y}{S_e} k M_r\right)$ and $\left(T_{av} + \frac{S_y}{S_e} k_t T_r\right)$ correspond to M and T in the static load equations,

$$\frac{S_y}{FS} = M \frac{c}{I} \tag{5}$$

and

$$\frac{(S_e)_y}{FS} = T\frac{c}{J}. \tag{6}$$

The equation for combined shear and direct stress is

$$\frac{(S_e)_y}{FS} = \sqrt{\left(\frac{\frac{S_y}{FS}}{2}\right)^2 + \left(\frac{(S_e)_y}{FS}\right)^2}. \tag{7}$$

The equation for combined moment and torque on a solid circular shaft (Eq. 8) is obtained by substituting Eqs. 5 and 6 in Eq. 7.

$$\frac{(S_e)_y}{FS} = \frac{16}{\pi d^3}\sqrt{M^2 + T^2}. \tag{8}$$

In a like manner the Westinghouse equation for the design of solid shafting (Eq. 9) is obtained by substituting Eqs. 3 and 4 in Eq. 7.

$$\frac{(S_e)_y}{FS} = \frac{16}{\pi d^3}\sqrt{\left(M_{av} + \frac{S_y}{S_e}k\,M_r\right)^2 + \left(T_{av} + \frac{S_y}{S_e}k_t\,T_r\right)^2} \tag{9}$$

or Eq. 9 can be obtained directly by substituting the equivalent fatigue values $\left(M_{av} + \frac{S_y}{S_e}k\,M_r\right)$ and $\left(T_{av} + \frac{S_y}{S_e}k_t\,T_r\right)$ for M and T in Eq. 8.

It can now be shown that the simple equations for static and for completely reversed loading are special cases of the more general equations. This is shown in Fig. 4 by points P' and P'' and can also be shown by making the appropriate symbols in Eqs. 3, 4, or 9 equal to zero.

This presentation follows closely the work that the student is already familiar with and is integrated with it. It should not remain as an isolated bit of his mental working equipment, or, as is often the case, never fully understood and soon forgotten.

THE T-SQUARE PAGE

Officers
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O. W. POTTER
T. T. AAKHUS
C. J. VIERCK
J. S. RISING
H. E. GRANT

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

J. GERARDI, *Editor*
University of Detroit

Officers
I. L. HILL
J. G. McGUIRE
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H. C. SPENCER
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ENGINEERING DRAWING SUMMER SCHOOL

Michigan State College

June 21–26, 1951

The Executive Board of the ASEE has formally approved sponsorship of the Engineering Drawing Division Summer School to be held in connection with the Annual Meeting at Michigan State College. This will start four days previous to the Society meetings which is Thursday, June 21, 1951, and conclude with our regular sessions allotted during the following week.

The general theme of this school will be "Improving our Status as Teachers of Engineering Drawing" treated on a basis of:

(a) Meeting curriculum requirements
(b) Teaching methods by lecture demonstrations
    1. Basic Drawing
    2. Descriptive Geometry
    3. Advanced Drawing
    4. Elementary and Advanced Graphics
(c) Industrial applications

Proposed program including time allotted during Annual Meeting

Thursday, June 21, 1951

Morning
8:00– 9:00 Registration.
9:00–12:00 Papers and discussions dealing with courses, administration reproduction, tests, credits, etc.

Afternoon
2:00– 4:30 Papers and discussions continuing with morning topics—Teacher Training, etc.

Evening
6:00– Dinner. Social gathering
7:30– Tour of displays with discussion by exhibitors. Directed by Committee on Exhibits

Friday, June 22, 1951

Morning
9:00–12:00 Teaching Methods. Lecture demstrations with discussion on Basic Drawing

Afternoon
2:00– 4:30 Teaching Methods. Lecture demstrations with discussion on Descriptive Geometry

Evening
7:30– Teaching Aids. Exhibits and discussion directed by Committee on Teaching Aids

Saturday, June 23, 1951

Morning
9:00–12:00 Teaching Methods. Lecture demstrations with discussion on Advanced Drawing
12:00– Group picture

Afternoon
2:00– 4:30 Teaching Methods. Lecture demstrations with discussion on Elementary and Advanced Graphics

Evening
6:00– Dinner. Executive Committee dinner

Sunday, June 24, 1951

Open for visits to Detroit, Ann Arbor, and Dearborn, University of Detroit, Wayne University of Michigan, Greenfield Village, etc.

Monday, June 25, 1951

Morning
9:00– Inspection trips

Afternoon
2:00– Conference. Industrial Application, papers and discussion

Tuesday, June 26, 1951

Morning
8:30– Inspection trips
10:00– Conference
12:00– Luncheon, Business meeting and Committee reports

Afternoon
2:00– Conference. Industrial Application, discussion

Evening
6:00– Dinner (ladies invited)
Awards
Jim Hays, Michigan State College "The Mechanical Cow"

The local committee at Michigan State College making arrangements at East Lansing for this Summer School consists of Professor C. L. Brattin, Chairman; O. W. Fairbanks; N. R. Sedlander; R. O. Ringoen (all of Michigan State College); Professor Philip O. Potts, University of Michigan; Professor Ralph T. Northrup, Wayne University; and Dean Jasper Gerardi, University of Detroit.

The Division is planning to exhibit student work in engineering drawing, course outlines, foreign drawings, drawing instruments and materials, visual aids and other displays which will be of interest to engineering teachers.

A cordial invitation is extended to all members of the Society who are interested in this program.

RALPH S. PAFFENBARGER, *Chairman*
Division of Engineering Drawing, ASEE
The Ohio State University

Candid Comments

The First Engineering School

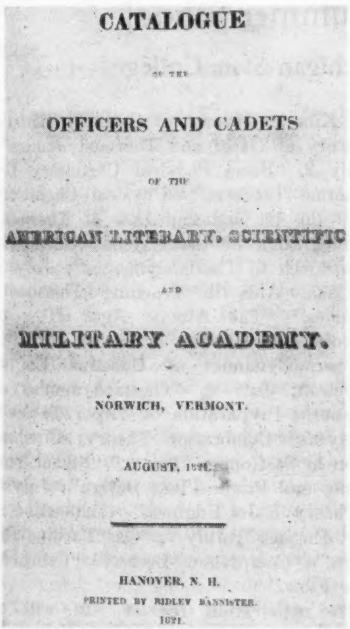
Referring to the article, "A New Approach to the Doctor's Degree for Engineers," by D. H. Pletta, in the November 1950 issue of the JOURNAL OF ENGINEERING EDUCATION.

I have just noticed in Table I, page 163 of the above, where it is stated in this table, that the first college course in engineering was that instituted at Rensselaer in 1828.

That statement simply perpetuates a long-standing error, namely, the idea that the first engineering course given in the United States was that at Rensselaer.

Enclosed is a reprint of our article in *Civil Engineering,* May 1950, page 68, relative to that historical fact of Norwich University being the FIRST EDUCATIONAL INSTITUTION IN THE NATION TO TEACH CIVIL ENGINEERING beginning in 1819.

Please notice that historical records show that a group of some twenty young men —who later became well-known Civil Engineers—received their early instruction in civil engineering at Norwich (then the Academy) in the period of 1819 to 1825. This was several years before Rensselaer had opened her doors, which in their own history, "History of the Rensselaer Polytechnic Institute" by Palmer C. Ricketts, they date as 1824,



CATALOGUE

OF THE

OFFICERS AND CADETS

OF THE

AMERICAN LITERARY, SCIENTIFIC

AND

MILITARY ACADEMY.

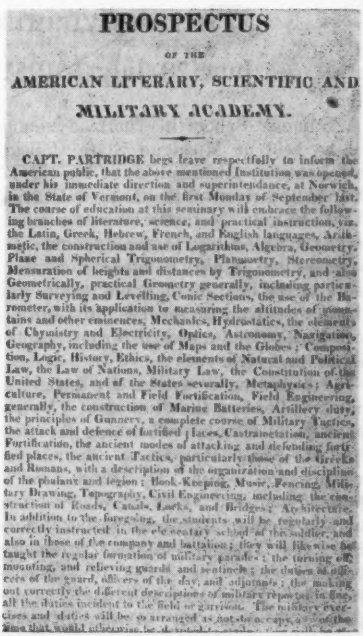
NORWICH, VERMONT.

AUGUST, 1821.

HANOVER, N. H.

PRINTED BY RIDLEY BANNISTER.

1821.



PROSPECTUS

OF THE

AMERICAN LITERARY, SCIENTIFIC AND

MILITARY ACADEMY.

CAPT. PARTRIDGE begs leave respectfully to inform the American public, that the above mentioned Institution was opened, under his immediate direction and superintendance, at Norwich, in the State of Vermont, on the first Monday of September last. The course of education at this seminary will embrace the following branches of literature, science, and practical instruction, viz. the Latin, Greek, Hebrew, French, and English languages, Arithmetic, the construction and use of Logarithms, Algebra, Geometry, Plane and Spherical Trigonometry, Planimetry, Stereometry, Mensuration of heights and distances by Trigonometry, and also Geometrically, practical Geometry generally, including particularly Surveying and Levelling, Conic Sections, the use of the Barometer, with its application to measuring the altitudes of mountains and other eminences; Mechanics, Hydrostatics, the elements of Chymistry and Electricity, Optics, Astronomy, Navigation, Geography, including the use of Maps and the Globes; Composition, Logic, History, Ethics, the elements of Natural and Political Law, the Law of Nations, Military Law, the Constitution of the United States, and of the States severally, Metaphysics; Agriculture, Permanent and Field Fortification, Field Engineering, generally, the construction of Marine Batteries, Artillery duty, the principles of Gunnery, a complete course of Military Tactics, the attack and defence of fortified places, Castrametation, ancient Fortification, the ancient modes of attacking and defending fortified places, the ancient Tactics, particularly those of the Greeks and Romans, with a description of the organization and discipline of the phalanx and legion; Book-Keeping, Music, Fencing, Military Drawing, Topography, Civil Engineering, including the construction of Roads, Canals, Locks, and Bridges; Architecture. In addition to the foregoing, the students will be regularly and correctly instructed in the elementary school of the soldier, and also in those of the company and battalion; they will likewise be taught the regular formation of military parades; the turning on, mounting, and relieving guards and sentinels; the duties of officers of the guard, officers of the day, and adjutants; the making out correctly the different descriptions of military reports; in fine, all the duties incident to the field or garrison. The military exercises and duties will be so arranged as not to occupy a part of the time that would otherwise be devoted to study; and each of the

first classes in 1825. The historical records of these twenty or more young men are in the files of Railroads by which these men were later employed in Civil Engineering work, and are also given in the three volume "History of Norwich University" 1819–1911.

Two of this very early group of some twenty young men, Norwich graduates of 1824, were Moncure Robinson, famous railroad engineer, and Alfred Wingate Craven, long chief engineer on New York City's early Croton water supply (both noted in the article reprint), (and also a third one, William S. Campbell, Norwich '28) were very active in the founding of the American Society of Civil Engineers. And Craven was the fourth President of the ASCE. Further, they are prominently recorded, several places, in the volume "Historical Sketch of the American Society of Civil Engineers" by Charles Warren Hunt.

Further, in Rensselaer's history by Ricketts, noted above, page 79, refers to the catalogue published in 1828, and also there refers to—"lectures on land surveying and civil engineering." And further quote from page 79, "This is the first appearance of the term 'civil engineering' in any of the circulars, and no well-defined course in the subject was formulated for several years." That was nine years or more after the beginning of Civil Engineering teaching at Norwich.

Norwich University thus precedes Rensselaer in the teaching of Civil Engineering by at least five years, before Rensselaer had opened her doors, or nine years or more by their own Rensselaer history taking their 1828 or "several years" later date.

DAVID L. SNADER
Head Department of Civil Engineering, Norwich University

Thermodynamics Summer School

June 28–July 7, 1951, Michigan State College

A Summer School in Thermodynamics will be held at Michigan State College, East Lansing, Michigan, June 28–July 7, 1951, at the close of the Annual Meeting of the ASEE. Methods of better teaching of the elementary thermodynamics will be presented as well as modern developments in the field of thermodynamics and a little on advanced theory. In addition, more background material for the teacher will be provided.

The following is a tentative program: June 28, "Leading the Student of Thermodynamics to Think," "Teaching the Concept of State Properties, Boundaries, Systems, etc."; June 29, "First Law of Thermodynamics," "Effective Presentation and Modern Approach to the Second Law of Thermodynamics," "Energy Transfer from the Laws of Thermodynamics," "Fluid Mechanics and Thermodynamics"; June 30, "Availability and Reversibility," "Mathematical Approach to Kinetic Theory of Gases," "Kinetic Theory of Gases and Thermodynamics"; July 2, "Basic Physical Chemistry for Thermo Teachers," "Physical Chemistry and the 1st and 2nd Law of Thermo," "Integration of the Physical Chemistry Approach to Thermodynamics"; July 3, "Visual Aids in Teaching Thermodynamics," "The Atomic Age: How to Equip Engineering Students for It," "Thermodynamics of Gasoline Engine Cycles"; July 4, "Thermodynamics of Vapors: Preparation of Vapor Tables"; July 5, "Combustion Theory: Combustion in Stationary Boilers," "Steam Turbines and Power Plant Design"; July 6, "Theory of Jet Engines," "Combustion in Jet Engines"; July 7, "Gas Turbine Design," "Compressor Design," "Compressor Flow."

A registration fee of $10 will be charged.

Shorter, Less Expensive Pre-Engineering Test Now Available

With the aid of the joint ASEE–ECPD Advisory Council the Measurement and Guidance Project in Engineering Education has devised certain improved testing services for engineering colleges.

I. To meet the need for a short, inexpensive, and easily administered test generally quite predictive of scholastic success in engineering colleges, *a new 80-minute Pre-Engineering Ability Test* will be offered for sale by Educational Testing Service on and after July 1, 1951.

Derived from the two most predictive parts of the Pre-Engineering Inventory, the new 80-minute test is estimated to have a validity nearly as high as for the composite score from the Inventory. Norms carefully equated to the original national norms will be furnished so that the test can be effectively used as soon as purchased.

A cost of 12 to 15 cents per examinee for test materials is made possible by separate answer sheets and reuse of each test book four to six times. Answer sheets and test books will be sold in packages of twenty-five; answer sheets for 80 cents per package; books for 40 cents each or $10 per package. Scoring stencils are 25 cents each (only one is needed). The sale of tests is restricted to colleges and to technical institutes accredited by ECPD.

II. After January 1, 1951, users of the Pre-Engineering Inventory who prefer to continue to use the four-hour "Short Form" or the six-hour "Long Form" may *purchase* test books, answer sheets, and scoring keys. Only engineering colleges and ECPD accredited technical institutes may purchase the tests. A cost of 50 to 60 cents per examinee is made possible by separate answer sheets and reuse of test books four to six times.

Under this new plan the costs are as follows:

	Test Books	Answer Sheets	Scoring Stencils
Unit of Sale	One book or one set of two books	Package of 25 sets	One set
Cost			
Short Form	$1.50 per book	$2 per package	$1 (4, one for each test)
Long Form	$2 per set of two books, I and II	$2.50 per package	$1.50 (7, one for each test)

Some of the test books may have been used previously but all are in excellent condition. Books usually can be reused five to eight times. Only the inexpensive answer sheets need be repurchased.

Educational Testing Service will score and report scores on an alphabetical list at a cost of $1 per examinee for the Short Form, $2 per examinee for the Long Form. For an additional $0.75 per examinee, distributions will be furnished comparing the group tested against national norms.

Individual announcements of these new services have been mailed to deans of engineering and to other interested persons. Further information may be obtained from Dr. A. Pemberton Johnson, Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner, Carnegie Institute
Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf, Northwestern University
Kansas-Nebraska	University of Nebraska	Fall, 1951	Kenneth Rose, University of Kansas
Michigan	General Motors Institute, Flint, Michigan	May 5, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	S. J Tracy, Jr., City College of New York
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University	Feb. 6, 1951	R. B. Allen, University of Maryland
	U. S. Naval Post Graduate School	May 12, 1951	
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	University of Nevada	Dec. 28–29, 1951	S. F. Duncan, University of Southern California
Rocky Mountain	Utah State Agricultural College, Logan, Utah	April 13–14, 1951	J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel, Biloxi, Miss.	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

New Members

ADLER, F. T., Associate Professor of Physics, Carnegie Institute of Technology, Pittsburgh 13, Pa. D. F. Miner, J. W. Graham, Jr.

ARCHER, OSCAR D., Dean, Lamar State College of Technology, Beaumont, Texas. L. B. Ryon, A. J. Hartsook.

BISCOE, JONATHAN, Associate Professor of Physics, University of Maine, Orono, Me. C. E. Bennett, W. S. Evans.

BISHOP, JOHN A., Associate Professor of Chemistry, Newark College of Engineering, Newark, New Jersey.

BRADY, SHERWOOD J., Assistant Professor of Engineering, San Jose State College, San Jose, Calif. R. J. Smith, J. H. Anderson.

CLARKE, CHARLES B., Assistant Professor of Civil Engineering, Rhode Island State College, Kingston, R. I. A. A. Collard, T. S. Crawford.

COOPER, GEORGE R., Assistant Professor of Electrical Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, H. A. Bolz.

Cornwall, Richard R., Instructor in Chemical Engineering, School of Mines, Rolla, Mo. F. H. Conrad, D. S. Epplesheimer.

CRISPEN, ROBERT E., Associate Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. H. Sutherland, P. F. Miller.

DOMINIC, RANDOLPH P., Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. F. P. Beer, P. F. Miller.

DURST, RICHARD E., Associate Professor of Chemical Engineering, University of Maine, Orono, Me. W. S. Evans, F. M. Taylor.

EPPES, JAMES VAN D., Associate Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa., P. F. Miller, J. B. Hartman.

ERKILETIAN, DICKRAN, H., JR., Assistant Professor of Mathematics, School of Mines, Rolla, Mo. R. M. Rankin, D. S. Epplesheimer.

GALE, GRANT O., Professor of Physics, Grinnell College, Grinnell, Iowa. A. B. Bronwell.

GEBHART, BENJAMIN, Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. P. F. Miller, M. C. Stuart.

GENTILE, JERRY J., Assistant Professor of Civil Engineering, Rhode Island State College, Kingston, R. I. A. A. Collard, T. S. Crawford.

ISBIN, HERBERT S., Assistant Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn. N. A. Amundson, N. H. Ceaglske.

JENTOFT, ARTHUR P., Graduate Assistant, Civil Engineering and Mechanics, Lehigh University, Bethlehem, Pa. W. J. Eney, P. F. Miller.

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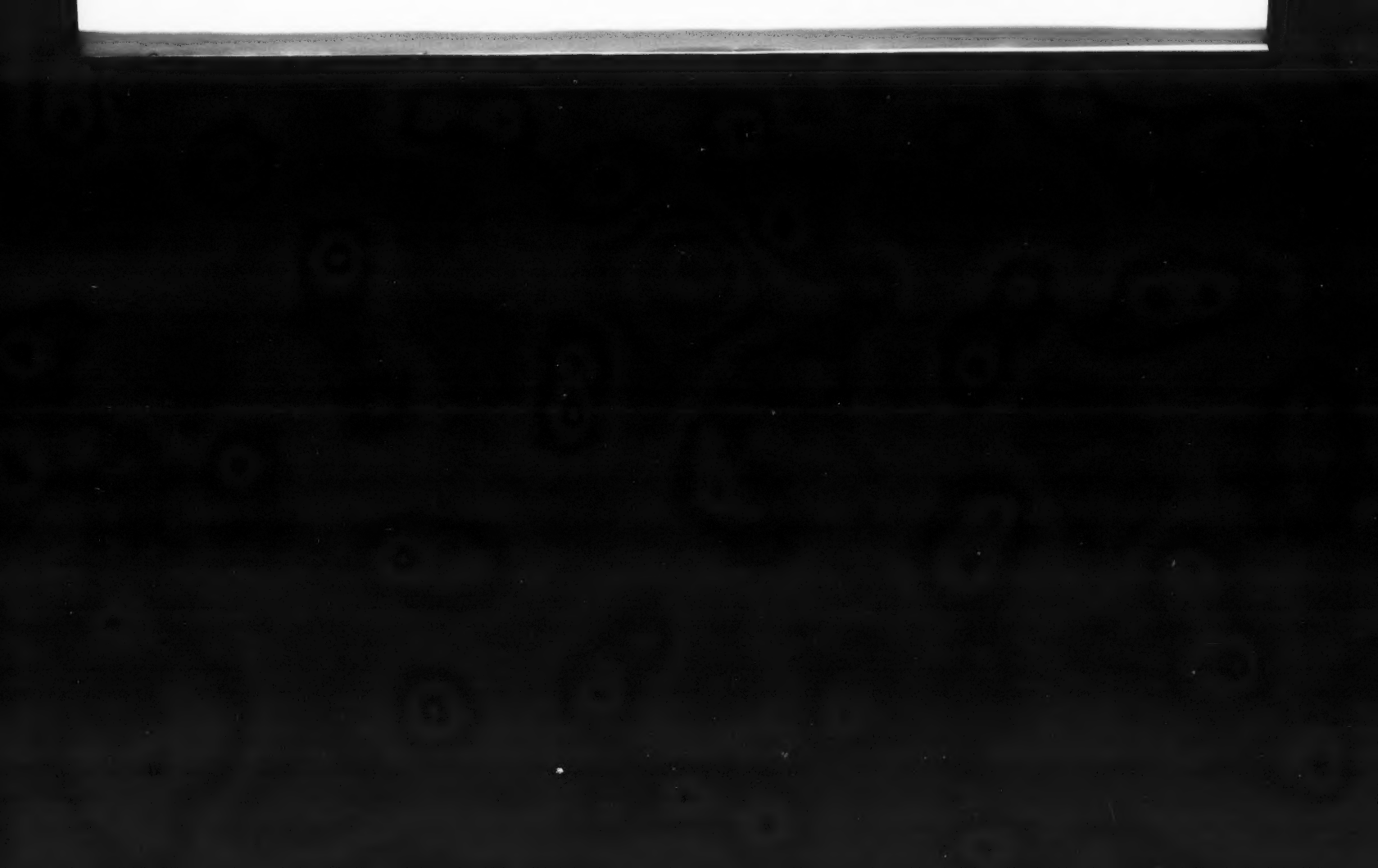

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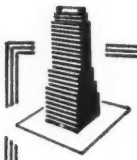

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